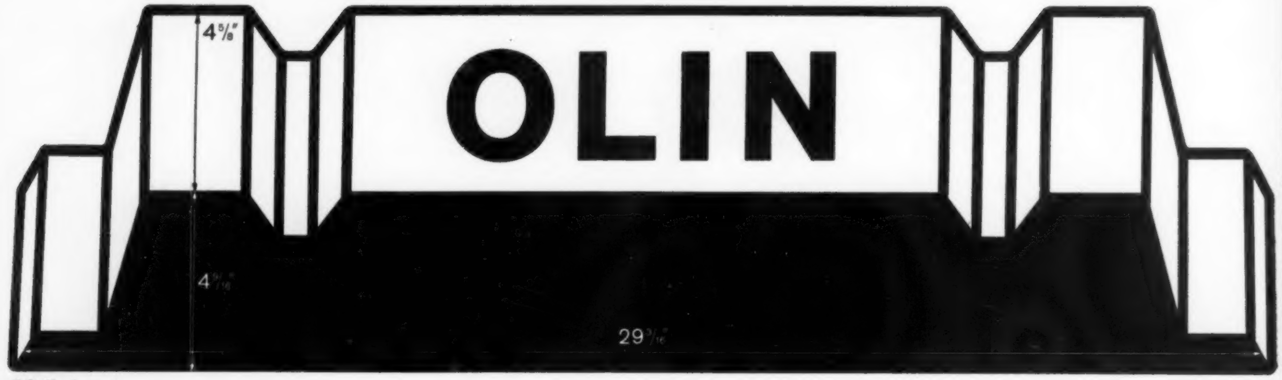
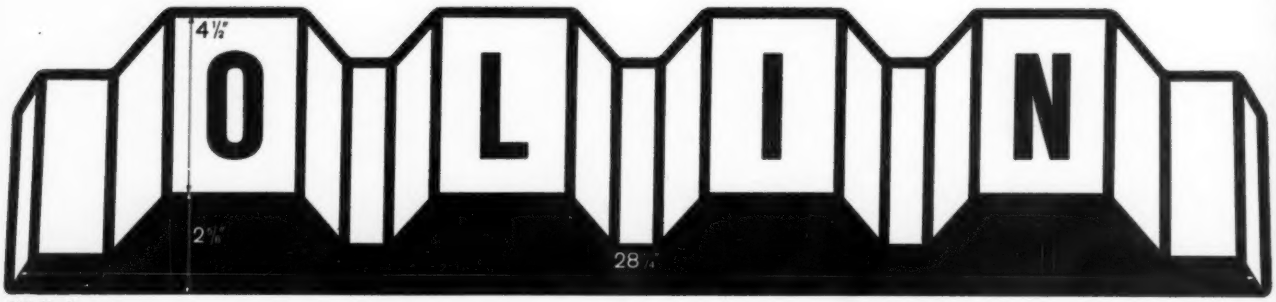
MARCH 1961

modern castings

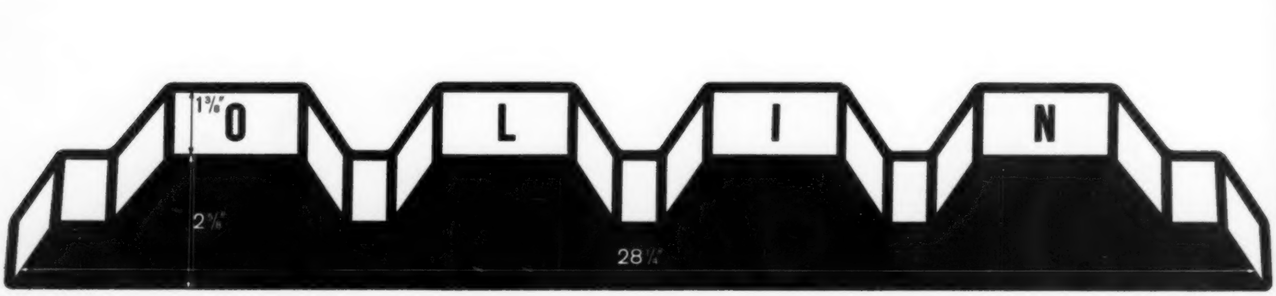
Cast
Pintle Shaft
Page 40



50-lb. ingot



25-lb. ingot



10-lb. ingot

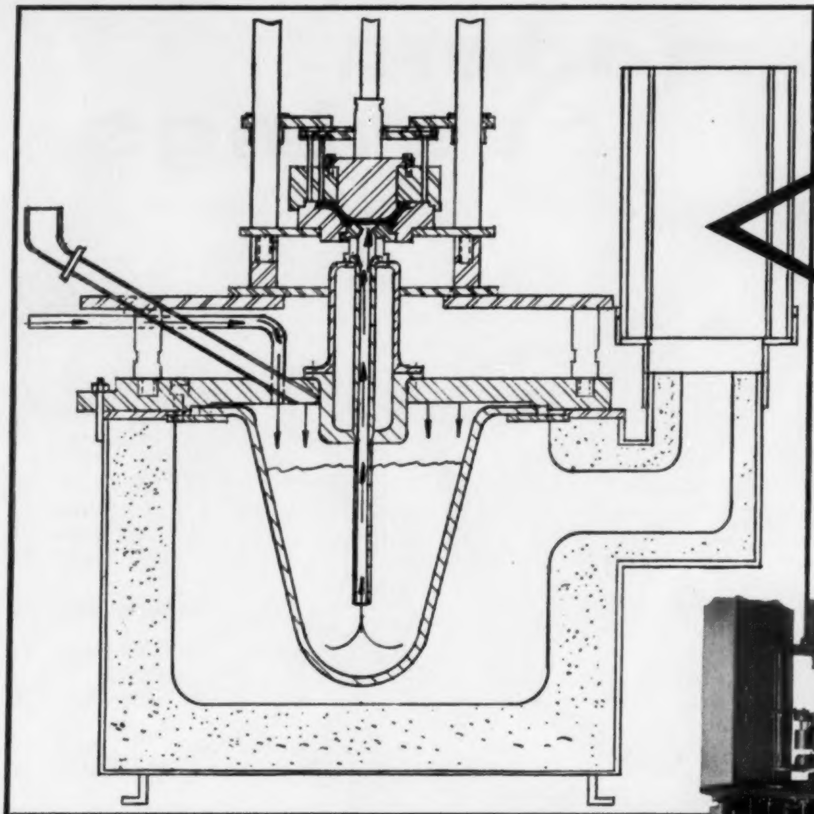
Castings?

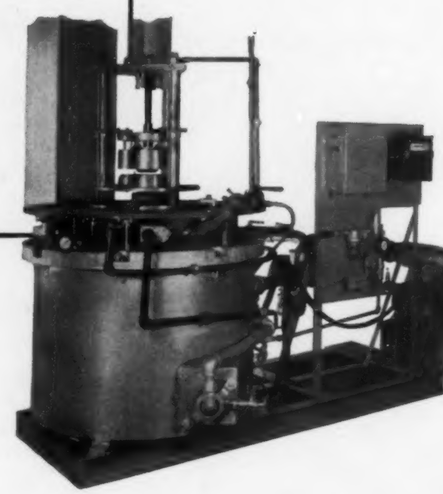
March 1961 Vol. 39, No. 3

modern castings

metalcasting "technology-for-profit"

MODERN CASTINGS is indexed by Engineering Index, Inc., 29 West 39th St., New York 18, N. Y. and microfilmed by University Microfilms, 313 N. First St., Ann Arbor, Mich.
The American Foundrymen's Society is not responsible for statements or opinions advanced by authors of papers or articles printed in its publications.
Published monthly by the American Foundrymen's Society, Inc. Publication office: 1309 North Main Street, Pontiac, Illinois, U.S.A. Editorial and executive offices: Golf & Wolf Roads, Des Plaines, Illinois. Subscription price in the U. S., $5.00 per year; elsewhere, $7.50. Single copies 50¢. May and June issues $1.00. Second class postage paid at Pontiac, Illinois. Additional entry at Des Plaines, Illinois.





PMD

What our experience means to you in . . .

LOW PRESSURE CASTINGS

Low pressure casting is occupying an important place in the metallurgical industries as a major development in the technique of permanent mold casting. The success of this type of casting is due, in part, to the technical knowledge and manufacturing skill of the personnel at Permanent Mold Die Company. Their experience makes it possible for PMD to offer you the finest quality low pressure casting machines available. These machines assure close tolerances and reduced trimming operations.

The PMD low pressure casting process deviates from the standard method only in the introduction of the metal to the mold. The mold is placed above a pressurized, airtight furnace; the molten metal is then forced through a tube into the mold from below. Pressure is held just long enough for the metal in the mold cavity to solidify, then it is released, allowing the excess metal to flow back into the molten bath.

It is obvious that the gating system can be simplified and the risers can be reduced to a minimum. These PMD machines greatly increase the ratio of net casting to the amount of metal poured. This results in a substantial reduction in production costs.

Write today for more detailed information about PMD automated molding machines and the savings they can mean to you.

FINISHED PRODUCT OF ABOVE DIAGRAM

This ashtray is an aluminum casting made from the PMD low pressure casting machine shown above.

PMD

PERMANENT MACHINE DIVISION

A Subsidiary of Permanent Mold Die Co.

2275 E. 9 MILE RD. • WARREN, MICHIGAN

Circle No. 123, Pages 145-146

modern castings

Golf and Wolf Rds., Des Plaines, Ill.
VAnderbilt 4-0181

Managing Director

Harold E. Green

Editor

Jack H. Schaum

Editorial Staff

Robert Minor, *Managing Editor*
George A. Mott, *News Editor*
W. R. Fingal, *Washington Editor*

S. C. Massari, *Technology*
H. J. Weber, *Safety, Hygiene and Air Pollution Control*
R. E. Betterley, *Education*
H. F. Dietrich, *Industry*
M. C. Hansen, *Castings Congress Papers*

J. S. Vanick, *Contributing Editor*—New York
J. F. Wallace, *Contributing Editor*—Cleveland
M. C. Flemings, *Contributing Editor*—Boston
W. D. McMillan, *Contributing Editor*—Chicago

Business Staff

Greta Maxfield, *Advertising Sales Liaison*
Mary McLean, *Advertising Production Manager*
Donna Pitkat, *Reader Service*
Mildred Michels, *Circulation Manager*

District Managers

Dwight Early & Sons Co.—Midwest
221 N. LaSalle St., Chicago 1
CEntral 6-2184

C. A. Larson & Assoc.—Eastern
254 W. 31st St., New York 1
LOngacre 4-4285

Pirnie & Brown—South-Southwest
1722 Rhodes-Haverty Bldg., Atlanta 3
JAckson 2-8113

Don Harway & Co.—Western
1709 W. Eighth St., Los Angeles 17
HUbbard 3-5141

John Ashcraft—European
67 Ave des Champs Elysees
Paris 8, France

Published by
American Foundrymen's Society

GENERAL MANAGER
WM. W. MALONEY

Let's look at . . .

Innovation! – and Leadership

H. E. Green

You cannot separate technology from the marketing of products. Top management must assume responsibility for product development as well as for the marketing aspects . . . Furthermore, the ability of a company to prosper depends on the closest possible relationship between technology and creative marketing. But innovation must come first!

Today, to survive, the metalworking industry must compete in a rapidly accelerating era of change—in markets, in intra-industry competition, in production, in other industry competition, and ESPECIALLY IN TECHNOLOGY. Since 1955 more than 50 per cent of the research and development *EVER* performed in this country has taken place. It's top management's job to be on top of all this *along* with the technicians!

This was the gist of a metalworking seminar held just recently in Chicago. And, *significantly*, this is Modern Castings' editorial and publishing platform.

Modern Castings functions as the common meeting ground of management and the technician—alerting, informing, helping, leading, innovating. Here are a few examples:

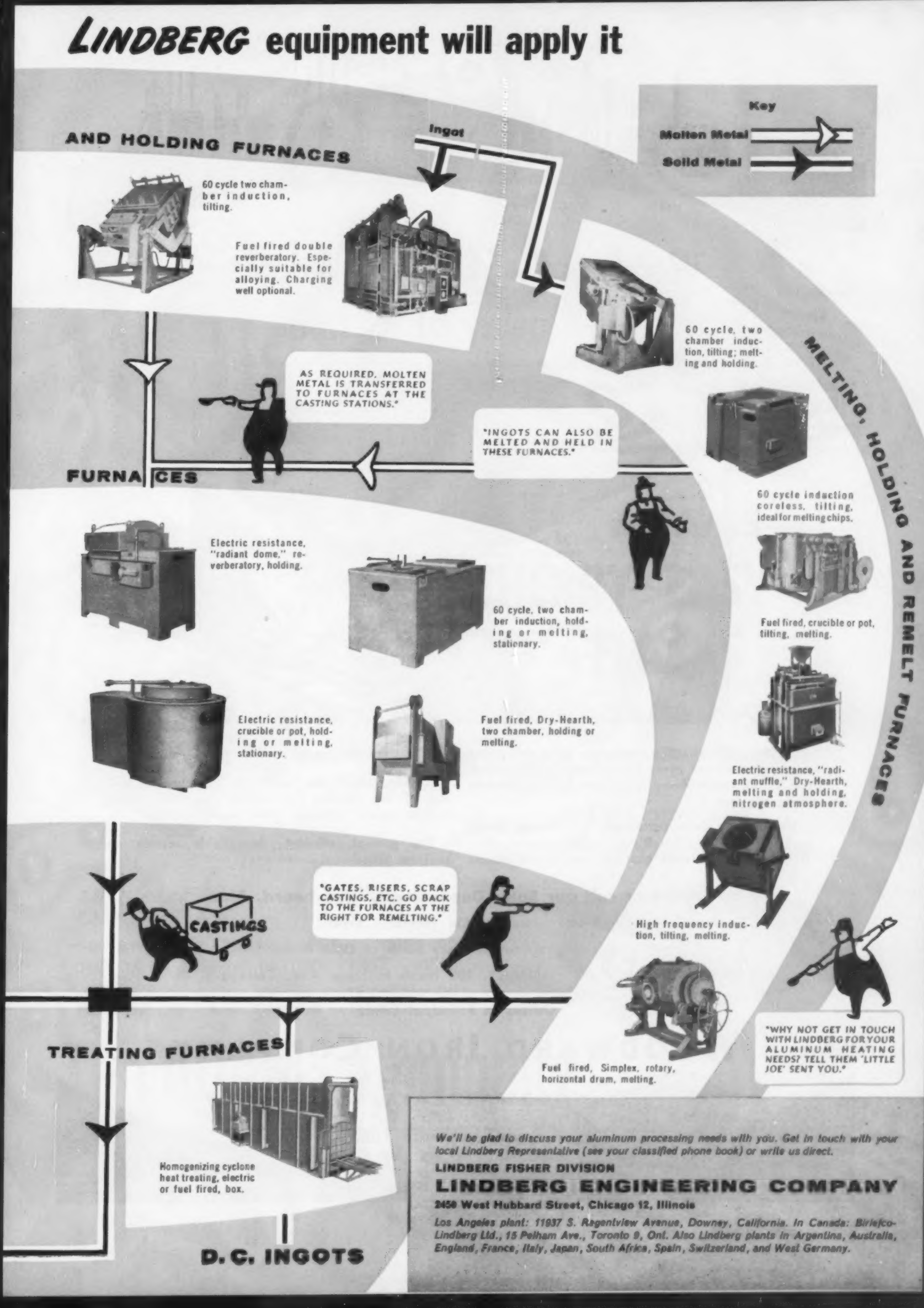
1. *The Marketing Opportunities Series.* This is designed to point out profit-making areas within metalcasting and also in *end-use* industries, such as materials handling and missiles. (See page 46, this issue.)
2. *The Technology-for-Profit Series.* This is a follow-up on the *practical* application of original research first published *exclusively* in Modern Castings. (See page 37 this issue.)
3. *The* Modern Castings *Metalcasting Trends Panel.* This is composed of leading executives in the industry. It is designed to speed up the flow of technological and marketing change to our readers—and the industry. (See our May Convention issue.)
4. *The* Modern Castings *"Invitational" Metalcasting Seminar.* To be held in conjunction with the 65th AFS Castings Congress in San Francisco in May, this seminar will look at industry problems in depth. (See our June Post-Convention issue.)

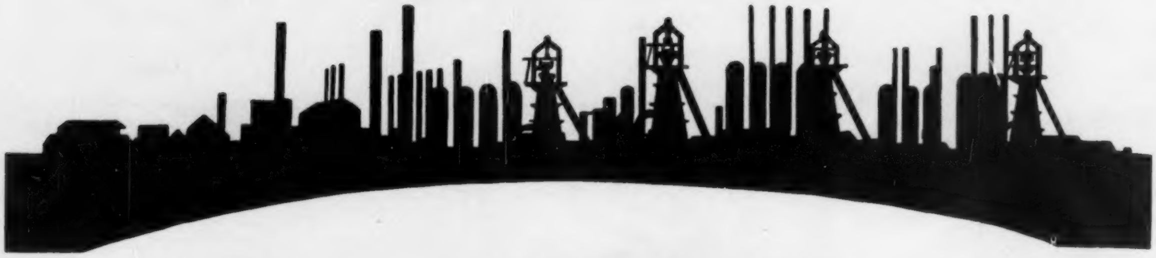
As you know, Modern Castings is the official reporting medium for the Congress—the year's top event in metalcasting! (See our June Post-Convention issue.)

In other words, top management and technicians alike *now* have a common meeting ground, Modern Castings, which is geared to their needs and the progress of metalcasting. This information is presented in professional journalistic format designed for both executive and technician. Our technology-for-profit image is an up-to-date leadership reflection of today's practical business needs: *products, markets,* and *profits.*

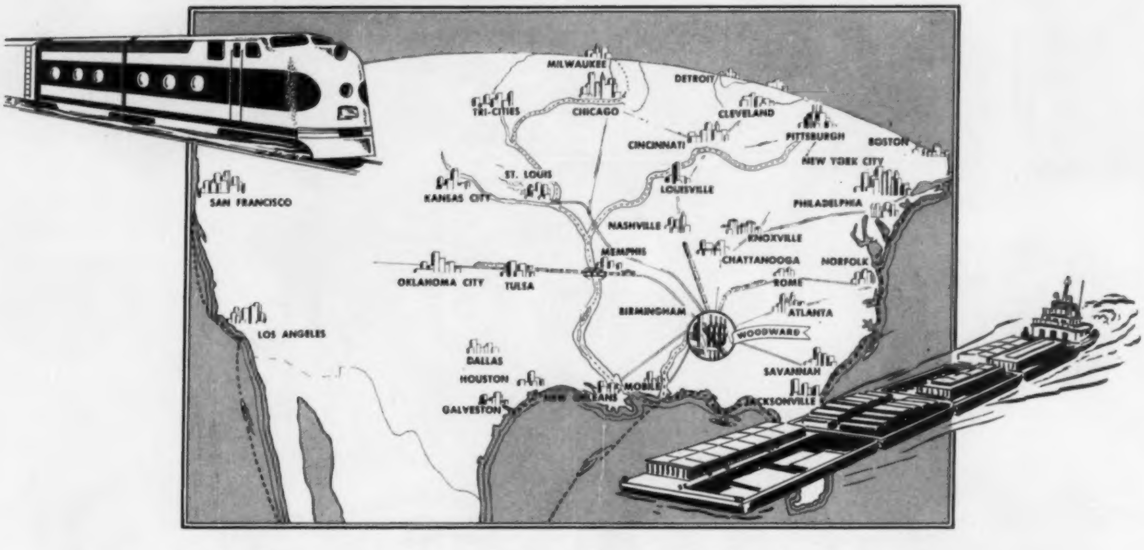
Harold E. Green


Wherever aluminum needs heat
LINDBERG FISHER
You'll find this nameplate on all the equipment you'll need for applying heat to aluminum. Heat and aluminum have been Lindberg's babies for years. Our staff of expert engineers, metallurgists and technicians is widely experienced in all phases of aluminum melting, casting, and treating and has pioneered many important developments in aluminum processing by heat. Today, Lindberg offers you a complete line of heating equipment for every requirement in this field. This includes every needed type of melting, holding or heat treating furnace, large and small, shop built or field erected, fuel fired or electric (resistance, 60 cycle induction, arc or high frequency). We hope you'll let our symbolic friend, "Little Joe", guide you through the exposition of this equipment offered on these pages.
Meet "Little Joe"! He looks something like a fellow in our plant but we really use him as a symbol of the good right hand of service Lindberg-Fisher's expert design staff and our complete line of "heat for aluminum" equipment is able to render you.
Hot Metal Delivery
MELTING
"RIGHT FROM THE START, LINDBERG EQUIPMENT TAKES OVER YOUR ALUMINUM HEATING NEEDS."
Fuel fired reverberatory. Charging well optional.
"MOLTEN METAL FROM REDUCTION CELLS IS HELD, OR INGOTS MELTED, IN FURNACES LIKE THESE."
CASTING STATION
Fuel fired reverberatory, holding or melting.
"MOLTEN METAL IS HELD AT THE CORRECT TEMPERATURE UNTIL PROCESSED INTO CASTINGS."
Fuel fired crucible or pot, holding or melting, stationary. New radiant wall type also available.
"MANY CASTING STATION FURNACES CAN BE EQUIPPED WITH THE LINDBERG AUTOLADLE, NAMED 'LITTLE JOE', AFTER ME."
Autoladle for automatic ladling, four shot sizes available, up to 100 lbs.
HYNI nitrogen generator, for atmosphere melting and fluxing.
SPECIAL EQUIPMENT
"SOME CASTINGS MAY REQUIRE HEAT TREATMENT AND THESE ARE HANDLED IN THE FURNACES BELOW."
Gas fired billet heater for extrusions.
HEAT
Cyclone heat treating, electric or fuel fired, box or pit.
60 cycle induction billet heater for extrusions.
"SO, DOWN TO THE FINISHED PRODUCT, LINDBERG EQUIPMENT TAKES CARE OF EVERY STEP."
Cyclone heat treating, electric or fuel fired, box or pit.
BILLETS
RODS
CASTINGS


LINDBERG equipment will apply it
AND HOLDING FURNACES
Ingot
Key
Molten Metal
Solid Metal
60 cycle two chamber induction, tilting.
Fuel fired double reverberatory. Especially suitable for alloying. Charging well optional.
60 cycle, two chamber induction, tilting; melting and holding.
MELTING, HOLDING AND REMELT FURNACES
AS REQUIRED, MOLTEN METAL IS TRANSFERRED TO FURNACES AT THE CASTING STATIONS."
"INGOTS CAN ALSO BE MELTED AND HELD IN THESE FURNACES."
FURNACES
60 cycle induction coreless, tilting, ideal for melting chips.
Electric resistance, "radiant dome," reverberatory, holding.
60 cycle, two chamber induction, holding or melting, stationary.
Fuel fired, crucible or pot, tilting, melting.
Electric resistance, crucible or pot, holding or melting, stationary.
Fuel fired, Dry-Hearth, two chamber, holding or melting.
Electric resistance, "radiant muffle," Dry-Hearth, melting and holding, nitrogen atmosphere.
"GATES, RISERS, SCRAP CASTINGS, ETC. GO BACK TO THE FURNACES AT THE RIGHT FOR REMELTING."
CASTINGS
High frequency induction, tilting, melting.
TREATING FURNACES
Fuel fired, Simplex, rotary, horizontal drum, melting.
"WHY NOT GET IN TOUCH WITH LINDBERG FOR YOUR ALUMINUM HEATING NEEDS? TELL THEM 'LITTLE JOE' SENT YOU."
Homogenizing cyclone heat treating, electric or fuel fired, box.
D.C. INGOTS
We'll be glad to discuss your aluminum processing needs with you. Get in touch with your local Lindberg Representative (see your classified phone book) or write us direct.
LINDBERG FISHER DIVISION
LINDBERG ENGINEERING COMPANY
2450 West Hubbard Street, Chicago 12, Illinois
Los Angeles plant: 11937 S. Regentview Avenue, Downey, California. In Canada: Birlefco-Lindberg Ltd., 15 Pelham Ave., Toronto 9, Ont. Also Lindberg plants in Argentina, Australia, England, France, Italy, Japan, South Africa, Spain, Switzerland, and West Germany.



Woodward's SERVICE Matches the Quality of its Iron



Among Woodward's customers are enterprises engaged in almost every line of merchant pig iron use in practically every State that has an industry using pig iron.

For serving these customers, both in the South and north of the Ohio River, the Woodward plant is strategically located near Birmingham, Alabama —the geographic center of the South.

Birmingham is the South's railway center and one of the region's few inland cities that enjoy regular nearby all-year water transportation.

For prompt, efficient, dependable service on uniform Woodward iron—

Write or call our Sales Department, Woodward, Ala.

Phone Bessemer, Ala. HAmilton 5-2491

or Sales Agents for Territory north of Ohio River:

HICKMAN, WILLIAMS & COMPANY, 230 North Michigan Ave., Chicago 1, Ill.

Offices in Principal Cities

WOODWARD IRON COMPANY

WOODWARD IRON COMPANY

WOODWARD, ALABAMA

Independent Since 1882

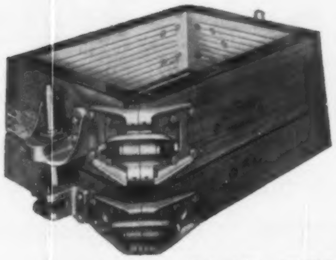
Circle No. 125, Pages 145-146

LARGE OR SMALL

ADAMS CHERRY EASY-OFF FLASKS

with ADAMS JACKETS

CAST IRON OR ALUMINUM



Patent No. 2898200
Other Patents Pending

To Complete
a winning combination

ADAMS CHERRY
EASY-OFF FLASK

PIN AND EAR ARRANGEMENT SUPPLIED TO SUIT YOUR PRESENT PATTERN PLATE GUIDES

Write us today for our circulars on Cherry Easy-Off Flasks and Cast Iron or Aluminum Jackets.

The ADAMS Company

ESTABLISHED 1883

MOLDING MACHINES and FLASK EQUIPMENT

700 FOSTER STREET, DUBUQUE, IOWA, U.S.A.

Circle No. 126, Pages 145-146

Looking at Business with Modern Castings

HOW TO MAKE SALES TODAY

How can the metalcasting industry grow today? Can it reverse downward trends in the consumption of certain cast metals, such as steel, malleable iron, and gray iron? How can product development and marketing be linked to make more sales and produce better profits?

One answer to these complex and pressing problems is being provided today by two leading vendors to the industry, Walter Gerlinger, Inc., and International Minerals and Chemicals Corporation.

Recently these two companies sponsored a Foundry Marketing Conference for their customers and prospects. The result was attendance by some 100 metalcasting executives, more than 30 of them company presidents.

Held in Milwaukee, the conference had four key ingredients of importance to individual metalcasters today:

1. It was designed to help them make better products and produce more sales.
2. It was staged by outstanding executives representing all phases of metalcasting—sellers, manufacturers, end-product users.
3. It was a "first", showing how individual companies—whether vendors or metalcasters—can help their customers and prospects make sales.
4. It was a program which identified and emphasized the most important phases of marketing in the metalcasting industry today.

Many leading executives cooperated to make the program possible. A look at the structure and people participating illustrates and emphasizes the importance of this "first" in the industry by private companies.

Assisting in putting the conference together were a gilt-edged group of metalcasting executives: N. N. Amrhein, president, Federal Malleable Co., Inc.; L. J. Andres, president, Lawson Foundry Company; J. B. Gutenkunst, president, Milwaukee Malleable & Grey Iron Works; Lawrence S. Krueger, vice president, Pelton Steel Castings Company; Thomas H. Tanner, president, Zenith Foundry Company; and J. Donald Zaiser, president, Ampco Metal, Inc.

Pacing of the conference was also significant. Formal talks were interspersed with two panel workships and audience par-

ticipation. Every important element of metalcasting marketing was given expert evaluation by selected authorities.

—The Customer's Viewpoint, Andrew J. Paul, assistant purchasing agent of all castings, Caterpillar Tractor Company.

—How Production and Sales Engineering Can Work Together, Ross L. Gilmore, president, Superior Steel and Malleable Castings Company.

—Requirements of a Good Salesman, Russell C. Johnston, sales manager, Industrial Division, Crown Iron Works.

—How Teamwork Develops New Business, Donald B. Fulton, vice president and general manager, Northern Malleable Iron Company.

—Sales Oriented Foundrymen, Thomas E. Barlow, foundry products sales manager, International Minerals & Chemicals Corp.

—Applying Modern Quality Control Methods to the Foundry, Harry S. Kindle, Jr., manager-quality control, Cummins Engine Co., Columbus, Ind.

—Building a Marketing Approach, A. E. Cascino, vice president—marketing, International Minerals & Chemicals Corp.

Summarized, the program was constructed to stress four areas: the basic interdependence of sales and production, the proper relationship between buyer and seller, what background a foundry salesman should have, and how alert foundries can combat price competition.

In substance, more than this was achieved:

1. The industry was provided with a practical pattern for industrial growth which companies, individually and in groups, can apply.
2. A greater interest in sound marketing techniques was achieved. The inportance of this cannot be underestimated (See pages 5 and 150).
3. A new dimension was added to educating metalcasters in marketing. It supplements the efforts of the industry's trade association to better marketing practices in specific metal areas.

Because of the people participating, and because of the program content, the Foundry Marketing Conference can be regarded as an important step forward in building new markets and more profits for the metalcasting industry.

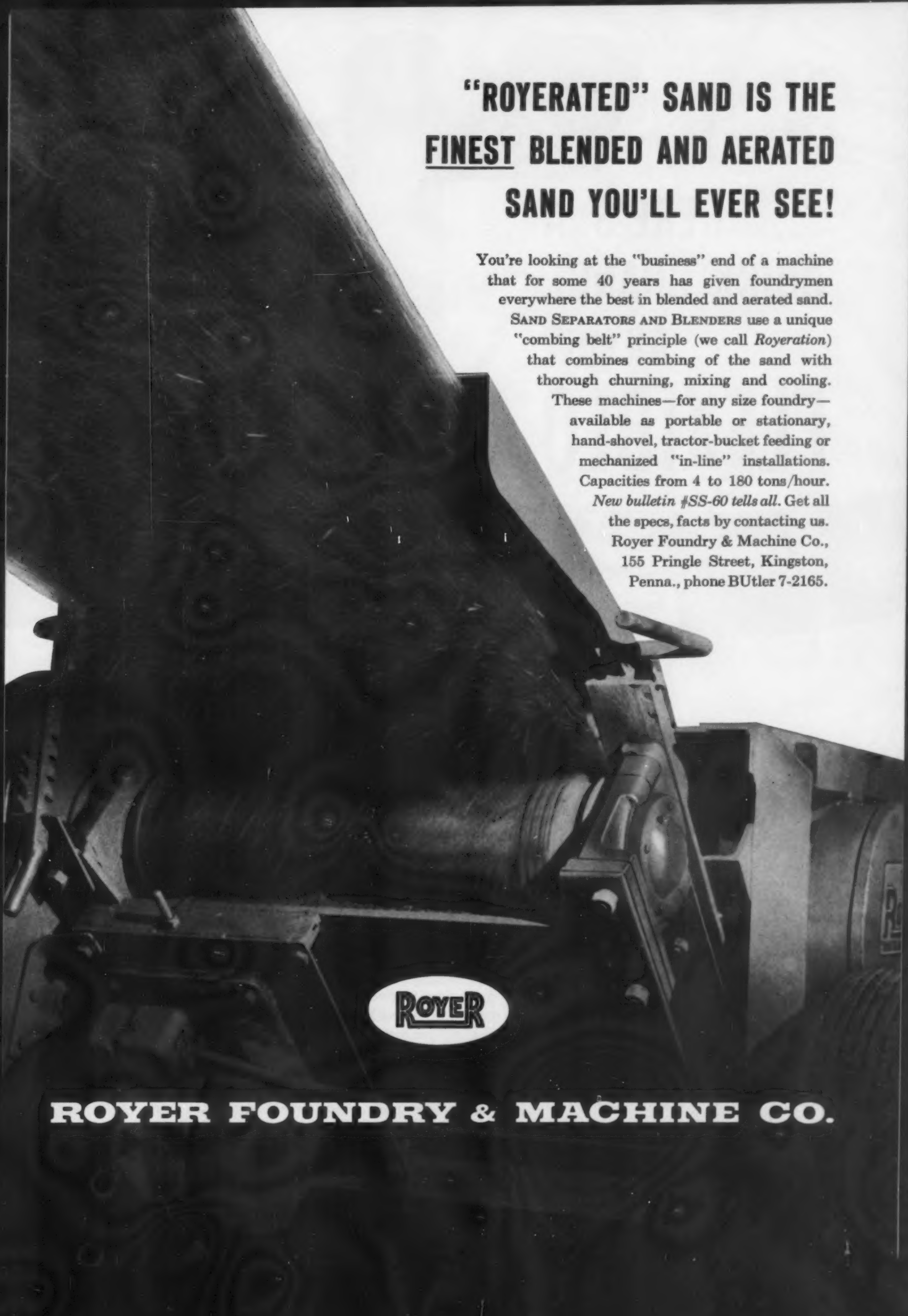
FERROUS SHIPMENTS

Shipments of gray iron castings in November totaled 836 thousand short tons, an increase of one per cent over the total for November, 1959, but a decline of eight per cent below October, 1960.

Malleable iron castings shipped in November totaled 63 thousand tons, one per cent below October but eight per cent above November, 1959. Steel shipments reached 100 thousand tons in November, three per cent below the October demand.

NON-FERROUS SHIPMENTS

November shipments of non-ferrous castings reached 177 million pounds, about four per cent below the October, 1960 figure. The total breakdown was 56 million pounds of copper castings, 63 million of aluminum and 54 million pounds of zinc. Also reported were shipments of 1.8 million pounds of magnesium castings, and 1.6 million pounds of lead die castings.


"ROYERATED" SAND IS THE FINEST BLENDED AND AERATED SAND YOU'LL EVER SEE!
You're looking at the "business" end of a machine that for some 40 years has given foundrymen everywhere the best in blended and aerated sand. SAND SEPARATORS AND BLENDERS use a unique "combing belt" principle (we call Royeration) that combines combing of the sand with thorough churning, mixing and cooling. These machines—for any size foundry—available as portable or stationary, hand-shovel, tractor-bucket feeding or mechanized "in-line" installations. Capacities from 4 to 180 tons/hour. New bulletin #SS-60 tells all. Get all the specs, facts by contacting us. Royer Foundry & Machine Co., 155 Pringle Street, Kingston, Penna., phone BUtler 7-2165.
ROYER
ROYER FOUNDRY & MACHINE CO.

Around the World with Modern Castings

NEW SOUTH WALES

A special drive to interest U. S. metalworkers in Australian manufacturing partnerships is underway. Over 30 metalworking firms in Sydney and the rest of New South Wales are currently seeking partnerships in the U. S. Dr. Arthur Denning, Commissioner for New South Wales, described such affiliations as "by far the best way for most American producers to reach the fast-growing Australian market." New South Wales claims to produce the world's lowest cost pig iron and steel and considers itself a perfect supply point to reach the hugh South Asia market. Already 1000 American corporations have invested $1 billion in Australia.

SWEDEN

A. B. Akers Styckebruk, the largest rolling mill roll foundry in Scandinavia, has installed a 30 ton, mains frequency, induction furnace. This is probably the largest furnace of this type operating in a foundry —another step in the trend toward electric melting.

ENGLAND

Something new . . . a bottom-pour, high frequency, induction furnace. Developed by the Group Research Laboratory, this furnace is a big step forward in guaranteeing cleaner steel castings. By bottom tapping the furnace only clean metal enters the mold. Slag on the top of metal is last to run out of furnace. Mixing action from lip pouring into a transfer ladle is also eliminated. A water cooled copper plug seals the bottom of furnace during melting.

ITALY

Cupola iron can be quickly and inexpensively inoculated by bubbling methane gas through it for 60-120 seconds. Work by Sofroni, Cosneanu, and Nicoloiu reveals that this simple flushing technique brings about a number of benefits: (1) tendency for internal shrinkage cavities reduced at least 50 per cent; (2) linear contraction diminishes 30-40 per cent; (3) graphite structure is markedly refined; (4) hardness of iron does not decrease; (5) strength increases; and (6) dissolved gases are removed. Reduced or eliminated are defects arising from gas porosity, shrinkage porosity, hot and cold tears, and residual stresses. All these desirable reactions to methane gas flushing means better quality castings.

FRANCE

The Gazal process for desulfurization of iron has just been announced by the Pompey steel plant in France. Recent "around-the-world" emphasis has been concentrated on producing lower sulphur iron and steel. Several devices, such as the rotating hearth, shaking ladle, and carbide injection, have already been reviewed by MODERN CASTINGS.

In the Gazal process, compressed air is bubbled through four or more porous refractory plugs installed in the bottom of a silica-alumina lined ladle. Bottom of ladle is covered with mixture of sodium carbon-

(*Continued on page 18*)

(*Continued from page 17*)

ate. As molten metal is poured into treatment ladle, air is bubbled through it. Resulting agitation speeds reaction between the slagging materials and metal. Sulphur is removed quickly from the iron to a level of 0.020 per cent or lower. Producers of ductile iron may find this technique useful for producing low sulphur iron suited to their needs.

RUSSIA

Super-high pressure molding is a mass-production reality at the Kremenchug road-building machinery works. Up to 400 molds per hour are produced on an automatic molding press which exerts over 2200 psi pressure on the sand. Case hardened steel patterns are necessary. When coarse sand is compressed, surface pressures exceeding 2940 psi create a thin layer of crushed, dense, and smooth sand on the mold surface. The course uncrushed sand backing this up provides adequate permeability.

Castings made in these molds are as smooth as those made in shell molds. Accuracies of 0.003-0.005 inches per inch can be achieved. The largest casting made thus far has a surface area over 100 square inches and is 4-inches high.

Some laboratory work with very high pressures has been done in the U. S. but to the best of our knowledge no foundry has yet reached the production stage.

CZECHOSLOVAKIA

Longer life can be achieved in water turbine castings and pump runner wheels by switching to 13 per cent chromium, 1 per cent nickel steel. After suitable heat treatment the castings display unusually good mechanical properties including remarkable resistance to corrosion, cavitation, and sand erosion.

A boom in hydro-electric power station building in Czechoslovakia has stimulated interest in improved castings for water turbines. Greater foundry skills are required in melting, pouring, rigging, and heat treatment but the superior results justify the additional effort.

UNITED STATES

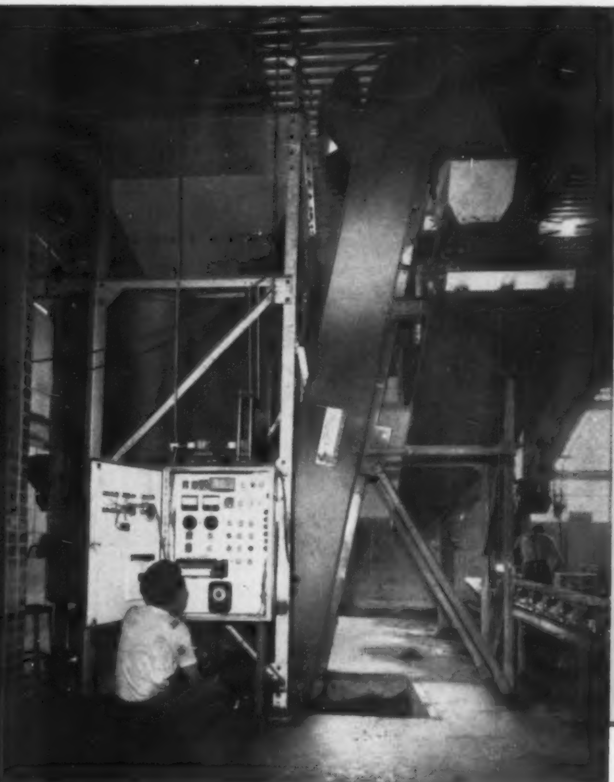
A seven-member U. S. Trade Mission visited Paris and six other major cities in France from October 5 through November 19, 1960. It operated trade information centers for one week periods at Bordeaux, Marseille, and Lyon.

The Mission concentrated its activities on the exploration of possibilities for further development of mutually advantageous trade and investment ties. It carried with it some 200 Business Proposals of U. S. firms who utilized the services of the Trade Mission to offer their French counterparts a variety of export, import, and licensing opportunities.

The Mission reported on 725 individual consultations which had been held with French businessmen interested in making contacts with the American business community. From these conversations, more than 300 tangible business propositions were developed.

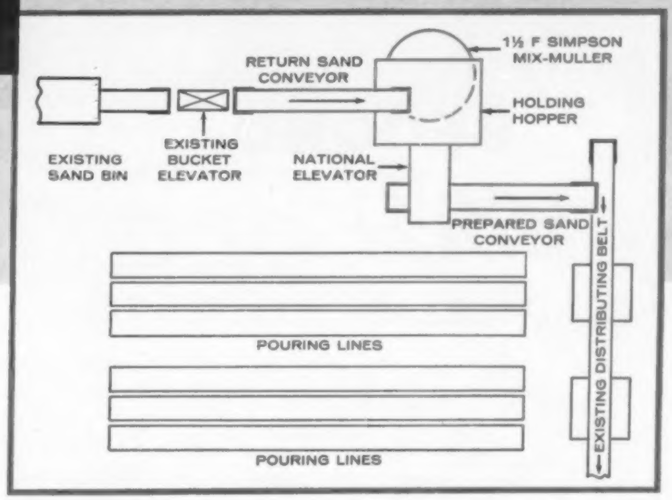
The Trade Missions program spearheads the international trade promotion activities of the Department of Commerce. The Missions are composed of businessmen and representatives of the Government working together as a team to develop increased commerce between the United States and all countries of the world. By person-to-person contacts and meetings with foreign businessmen and Government officials, the opportunities are explored for the exchange of import-export trade, investments, joint ventures, and other business relations.

increased our production by 15%"



At Prier Brass, 1000 lb. batch is prepared every 1 min. 45 sec. in this 1½F Mix-Muller. Unit is charged by automated batch control system. Moisture is controlled by automatic injection device.

Elevayor returns sand to distributing belt via cross belt. Note chutes used to accumulate spill sand at central point.



Sketch of Prier Brass layout points up compactness of National **Mechani-Mize** preparing plant. All layouts, engineering, erection and start-up were handled by National.

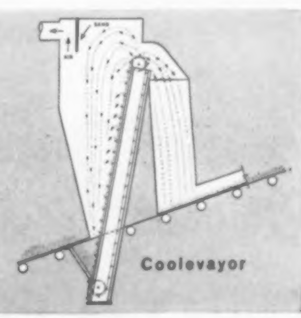
F960

MECHANI-MIZE Foundry-wise

. . . with National unitized equipment specifically designed to help you get sand up off the floor without major plant change or big equipment investment.

Screen Master

Molder's Helper



Coolevayor

Circle No. 133, Pages 145-146

Reader Opinions and Ideas . . .

WANTS NOISE DATA

We are presently conducting a noise survey for our ferrous and non-ferrous foundries. As I see it, we have two ways of corrective action. 1–Inaugurate a compulsory ear protecting program in the areas. 2–Correct the noise at the source through enclosures or other means.

Our principal problems lay in shakeouts, cleaning barrels, sand mixing equipment, and core machines.

What information have you on this subject?

J.A.H.

Editor's Note: I am forwarding you a copy of our Foundry Noise Manual. Herbert J. Weber, Director AFS Safety, Hygiene and Air Pollution Control program.

REQUEST FROM ISRAEL

An assistant of mine would like further gray iron foundry experience in the United States. Azriel Morag has worked for me in the foundry laboratory doing development work, principally on sand and casting defects. He has also designed and installed equipment.

Azriel will complete his BSc studies in July, 1961 and will then be available for employment. He is looking for experience in the United States to broaden his background. His father owns a foundry in Tel-Aviv to which he would return after employment in your country.

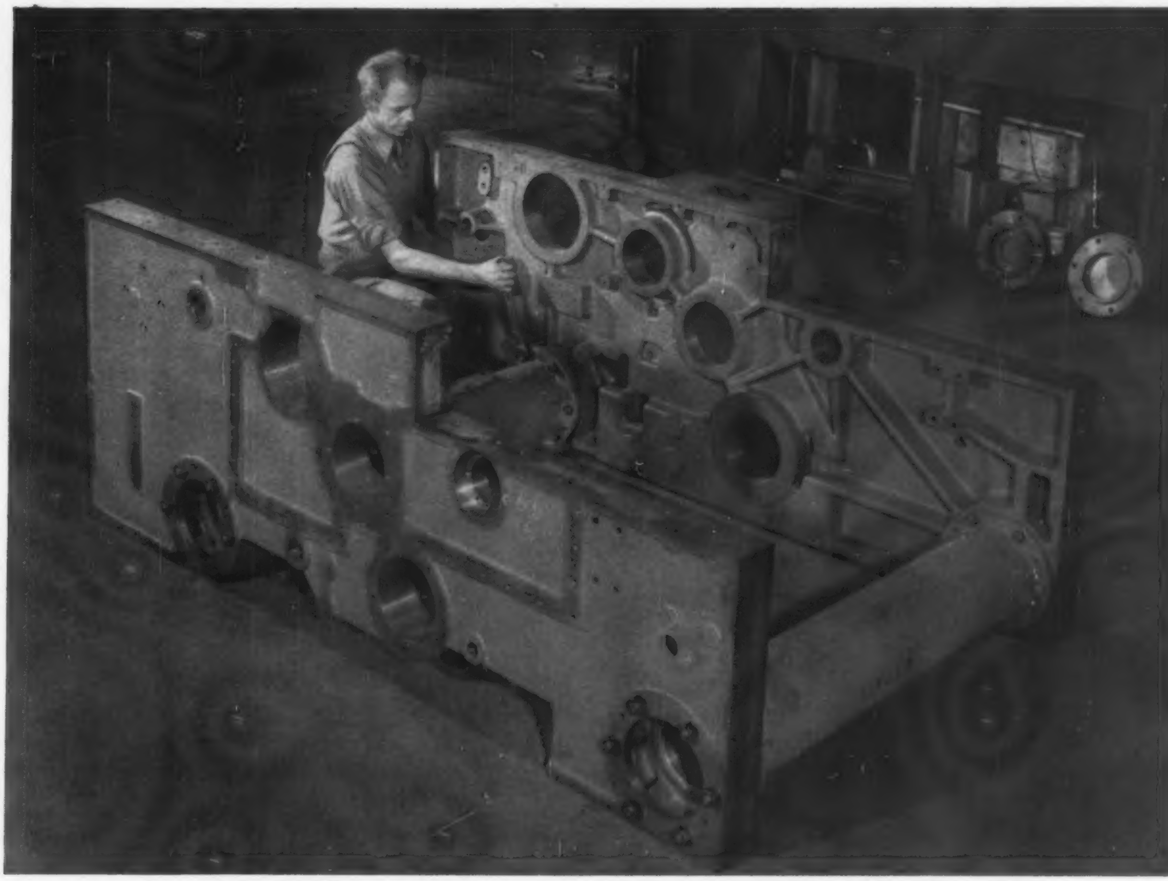
Isaac Minkoff
Dept. of Metallurgy
Israel Institute of Technology
Haifa, Israel

SUGGESTION FOR CLEANING

We use numerous gray iron cast sheaves. Ductile iron is now being used for both the jackshaft and final drive sprockets.

We believe that the quality of these two sprockets could be improved if some rapid broaching or machining could be devised to clean up the cast tooth form. Present suppliers are doing considerable handwork with a small grinding tool to clean up individual teeth.

Broaching or a gang setup where



1300 pound cast frame for large high speed bag-making machine. L. Brayton Foundry Co. uses a 1% nickel cast iron for frames to assure accurate alignment of shafts and cross members during assembly by St. Regis Paper Company, East Providence.

How nickel irons help you maintain control of large, complex castings

One of the easiest ways to obtain dimensional stability in a big, intricate casting is to use a nickel cast iron.

Take the matched frame members shown above, for example.

You'll see the problem right away. Unless cored holes and to-be-machined surfaces line up almost perfectly . . . up go machining costs.

Now notice the heavy bosses and ribs. And take note that the supporting web is ½-inch thin. You would expect some chill in this web and a tendency to warp. And you might forecast a costly stress relief or expensive set-up time in machining operations.

L. Brayton Foundry got around all this quite easily. By using a nickel cast iron mix, they were able to deliver these frames "as cast" and meet all requirements for dimensional accuracy.

Nickel irons give you more control over chill...help keep warping stresses low

Nickel cast irons show less tendency to chill. With these irons, structure is more uniform. Build-up of internal warping stresses in large, complex castings is not as high.

What's more, selection of the right grade of nickel iron gives you improved control over structure, and hence, machinability, wear resistance, strength and other properties desired by you and your customers.

Pass on to your customers the benefits of nickel cast irons

Next time you have an order coming up for a large, complex casting, look into the economics of nickel cast irons. You may be able (1) to reduce your own costs or (2) to provide your customer with a much better casting.

Maybe you can do both. The way to find out is to contact Inco. Inco's engineering service can help you . . . on either a special foundry problem or to help convince a customer.

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street New York 5, N.Y.

INCO NICKEL

NICKEL MAKES CASTINGS PERFORM BETTER LONGER

rapid machining for cleaning the rough cast tooth might be possible at considerably less cost. We feel that this is an area which would greatly increase the acceptance of cast tooth sprockets.

R.A.

Editor's Note: Here is a good demonstration of a metalcasting buyer helping foundries to make a more competitive product. Perhaps it will suggest other applications where the end product cost can be reduced.

USING GRAPHITE CLOTH

In the September, 1960, issue of MODERN CASTINGS your Editor's Report mentioned a new material called graphite cloth. Our thought on a possible application for such a material has to do with protecting a concrete floor in our pickling department.

Our stainless steel castings are given a bright pickle in a rather mild solution of nitric-hydrofluoric acid. The concrete floors in the pickling department are destroyed very rapidly if they are not thoroughly protected from spillage of this solution and rinse water.

One method of protecting the concrete consists of applying a coating of epoxy resin containing a filler of carbon powder.

We would like to explore the possibilities of using the graphite cloth as reinforcing in the epoxy coating, much the same as using fiber glass cloth in making epoxy laminates for patterns.

Would you furnish us with the name of manufacturers or suppliers of the graphite cloth?

B.S.

Editor's Note: In the September article a request was made for suggested use of the graphite cloth. Here is how one ingenious foundryman sees a possible application.

MELTING VS. SMELTING

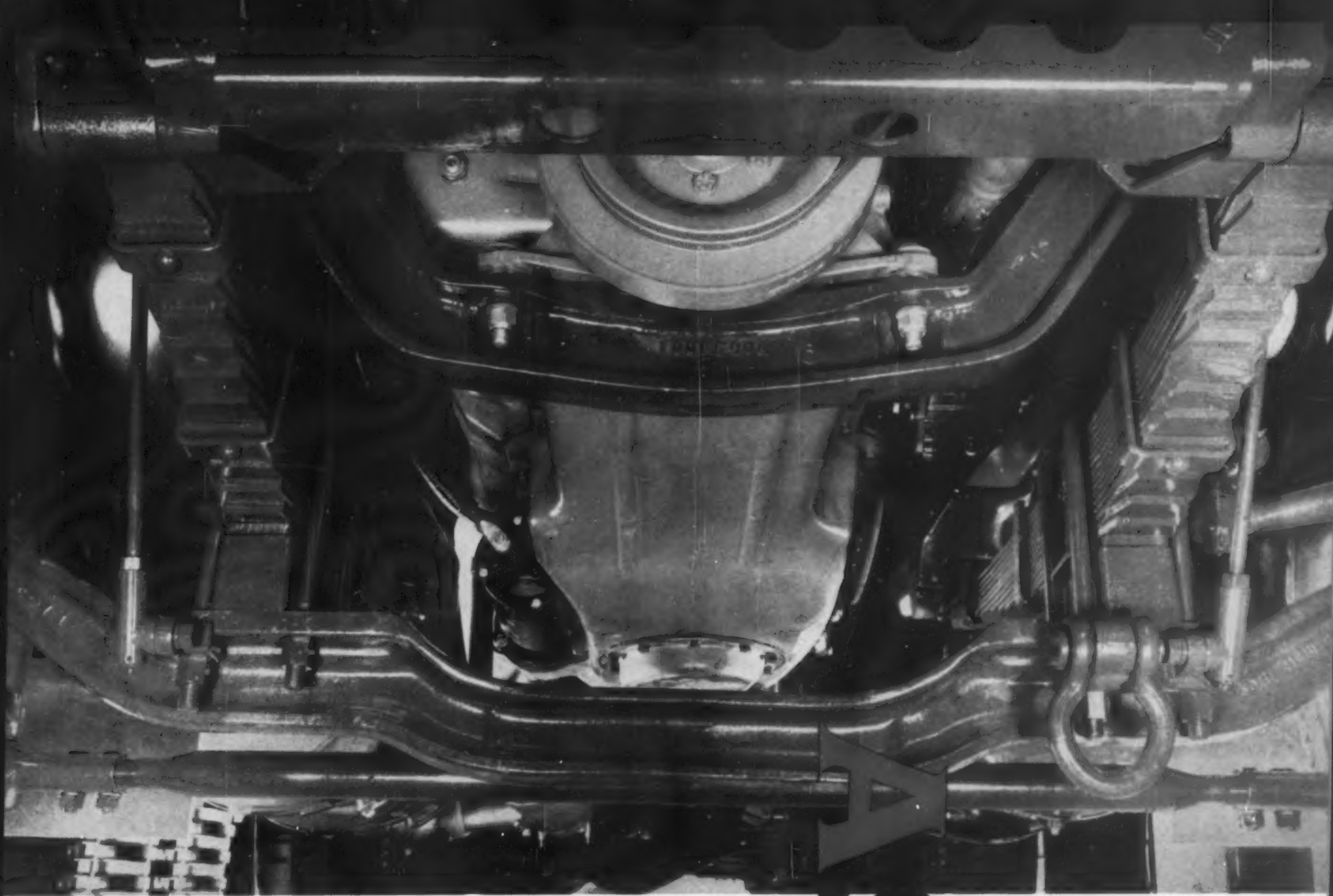
Quite a few non-foundry people come into our plant, and I have shown them around, explaining our workings in general and the workings of our cupola in particular.

One question which comes up over and over again is:

"What is the difference between melting and smelting?"

I have looked in different publications for the *right* answer, but have had no luck in finding an answer that spells the difference clearly.

I would appreciate any help you



Circle No. 136, Pages 145-146

care to give this perplexed Foundryman.

F.P.P.

Editor's Note: The term "melting" is applied to the process of changing a solid to a liquid, and specifically, as applied in the foundry industry, is the act of converting solid metal to a liquid state.

By comparison, "smelting" is applied to the process of reducing an ore by a chemical process, usually at elevated temperatures, to the metal contained in the ore. As an example, smelting is applied to reducing iron ore to pig iron in the blast furnace. Melting, then, is only converting a metal from the solid to the liquid state. Smelting is used to designate the process of reducing an ore to a metal.

THANKS FOR INFORMATION

Thank you for your informative materials. Your AFS Speakers List is certainly impressive. I am looking forward to meeting and hearing these men.

BLAINE M. SWARTZ
Chief of Procurement
Aircraft Armaments, Inc.
Cockeysville, Md.

PISTONS TO FURNITURE?

We have purchased a large volume of aircraft pistons of A-132 alloy from the government. We plan to melt these pistons in a 250 lb. cast iron melting pot and use the molten metal to pour sand castings for our ornamental furniture. Is there any material that we can add to the molten metal in the pot that will refine the grain structure of the metal so that the castings will have maximum strength and ductility.

W.E.S.

Editor's Note: The A-132 alloy which you have contains about 12 per cent silicon along with one per cent magnesium, and it is not a desirable alloy for sand castings, being especially adaptable to either die or permanent mold casting where solidification occurs very rapidly.

This alloy is of a type known as age-hardening, and if cast into ornamental furniture will be quite brittle and will become increasingly brittle by precipitation hardening at ordinary ambient temperatures.

It is definitely an alloy which should be heat-treated if you are go-

 →

ing to use it at all. In order to avoid the brittle character, it is necessary to solution heat treat it by heating it to 450 to 475 F and holding it at this temperature from eight to 12 hours.

TECHNICAL PAPERS

We are interested in obtaining the procedures for the preparation of technical papers for publication. Most likely you have certain requirements which you ask the authors of papers to follow in the presentation of graphs, figures, tables, illustrations and the like.

W. M. Steinecke
Division Head,
Technical Information
Bethlehem Steel Co.
Bethlehem, Pa.

Editor's Note: Those interested can write for our AFS "Guide to Authors" and our Offer of Technical Paper forms.

THREE-INCH CUPOLA

Can you supply information on construction of a small, three-inch diameter cupola? I understand that such a cupola is being used by some in metal casting research.

F. A. Hames,
Chairman
Metalurgical Eng. Dept.
Queen's University
Kingston, Ontario

Editor's Note: There was an article in the May, 1949 issue of MODERN CASTINGS. Those interested in more *information can write to Dr. Fred C. Barbour, Chief Chemist of the McWane Cast Iron Pipe Co., 1201 Vanderbilt Road, Birmingham 2, Ala.*

COMPLEMENT FROM ENGLAND

We are most impressed by the special report "Rapid Obsolescence of Machine Tools," by Editor Jack Schaum in the December, '60 issue. Our foundry is engaged in the production of machine tool castings in grey iron, for our parent company.

We could use 12 extra copies.

F. G. Hanton
Foundry Manager
George Richards & Co., Ltd.
Altrincham, England.

WITH TAYLOR ZIRCON RAMMING MIX

Mould Manufacturer cuts induction furnace lining costs by

50%

Pouring a heat of grey iron from 650 lb. high frequency induction furnace lined with TAYLOR ZIRCON No. 717 Ramming Mix.

TAYLOR ZIRCON No. 717 Ramming Mix has cut refractory lining costs *in half* for a mid-west mould manufacturer. In addition, average number of heats has increased. This company melts grey iron in 650 lb. and 1000 lb. induction furnaces to produce moulds for the glass industry.

Alert foundries are standardizing on TAYLOR ZIRCON Ramming Mix as the most economical lining for high frequency furnaces. High softening point, low thermal conductivity, high di-electric strength, and volume stability make TAYLOR ZIRCON an excellent refractory for this service. For detailed information, write direct, or call in a Taylor field engineer.

Exclusive Agents in Canada:
REFRACTORIES ENGINEERING AND SUPPLIES, LTD.
Oakville, Ont., and Montreal

The CHAS. TAYLOR SONS Co.
A SUBSIDIARY OF NATIONAL LEAD COMPANY
REFRACTORIES SINCE 1864 • CINCINNATI • OHIO • U. S. A.

Circle No. 140, Pages 145-146

What Qualities Do You Want in a Foundry Foreman?

by H. F. Dietrich

Of the qualities necessary in a foundry foreman, which is the most important?

To this question some might answer, "A complete knowledge of foundry practice." To a degree this would be true. Although it would be silly to place a cookie-maker in charge of a foundry crew, it has been done—with success. I know because I worked under one and he did a better job than some old-time foundrymen I have seen.

Because he hadn't been in the foundry long enough to learn foundry tradition, he hadn't developed inhibitions. Unlike many old time foundrymen, he didn't know that a thing couldn't be done; so, he went ahead —in his stupidity—and did it.

Working on the premise that "a little knowledge is a dangerous thing", and that no one man is master of all the knowledge in the world, Boss Kettering, of automotive fame, seldom put a specialist to work on a problem. He reasoned that a man with intelligence and common sense could find a solution because he didn't know, as the expert did, that a job couldn't be done.

Many top executives in the foundry business today couldn't make a rolling cheek mold if their lives depended on it. Under almost every foreman are men who have worked in the foundry longer than he . . . men who can make a better mold; men who can do a better job of pouring. Complete knowledge of foundry practice, then, is not essential to the success of the foundry foreman.

Perhaps it is academic achievement that is required in these days of education consciousness? One of the most successful foundrymen I knew had trouble getting out of the sixth grade. He went to a rural school that burned down and was never rebuilt. (Rumor had it that he helped burn it.) However, without the help of a teacher to tell him which page of the book to read, he managed to pick up quite an education in running a foundry.

Of those who are formally educated, very few successful foundrymen have more than the bachelor's degree. Although it is helpful, a college degree is not indispensable to the successful foundryman.

Because the foundry foreman is a businessman—of sorts—perhaps a knowledge of business principles is necessary to success. It is true that a foundryman who doesn't understand the relationship of cost to profit is a prime candidate for a beachcomber's job.

But we are living in an age of specialists. We can hire an expert for almost any area.

Following this line of thought, a foreman need not be a better mechanic than the men under him. He doesn't need to be completely educated in a formal institution. He doesn't have to qualify as a business expert. But there is one quality without which no foreman can be successful. He must have—and be able to use—*common sense*.

This is the quality in a man that tells him when a gate is too small for a job. It warns him that metal is too cold for a light casting. It improves his relationship with other men. It is the one facet of his personality most respected by the men working under him. Men lose confidence in the featherheaded bungler regardless of his alphabetical title. They prefer to work for someone who can talk to them on a common sense level.

In the foundry especially, *there is no substitute for common sense.*

Communications . . . An Industrial Headache

By R. E. Betterley

Last month (Modern Castings, February) this column initiated the first of a four-part series, discussing "The Importance of Communications."

Because it plays such a large part in our daily lives, there is a tendency to assume we fully understand communications. Our awareness of the various *means of communicating,* such as speech, writing, and the mass-media of radio, television, newspapers, etc., further cements this assumption. Serious communications failures have resulted from this basic weakness. The means of communication are important; however, they should be accepted only as such and not construed to be the communication process itself. This, as we pointed out last month, entails much more . . . the sharing and mutual understanding of an idea or concept through *two-way* interchange of information. Then, and only then, complete communication exists in the full sense of the word. For effective communication, plant management must fully understand the *means* as well as the process.

Management might be shocked to learn of the effectiveness of its *own* communications. Tom C. Campbell, Editor-in-Chief of "Iron Age," in the December 15, 1960 issue, gives figures developed by the advertising and communications firm of Savage-Lewis Corporation, Minneapolis, as follows: "When the president or board of directors gives the 'word,' what happens? Here goes: the V.P.'s understand about 67 per cent of it; general supervisors get 56 per cent of it; 50 per cent reaches the plant manager. The foreman understands 30 per cent, and guess what? The worker gets 20 per cent."

Industrial communications largely employ sight and hearing. It is noteworthy to consider the strengths and weaknesses of communications in terms of the methods and senses used. We know, for example, the written word is not 100 per cent effective. It has often been said, "One picture is worth a thousand words." The written word does, however, provide a permanent record and can be carefully prepared in advance.

The importance of spoken communication should be emphasized as this form represents most of our daily communicating. Too often plant personnel are lacking in their ability to accurately speak their ideas. Spoken words can, also, be misleading in meaning and interpretation. Distractions, noise, inattention and questions hamper the speaker. Frequently such interchanges are "one shot" operations and when occurring in the cleaning room, for example, "getting through" with important instructions is highly questionable.

Combining the methods and senses employed produces better results. Action—*alone*—in many cases erases the intent and effectiveness of the communicator. Likewise, it can also enhance the process. No one will challenge the truth of the old saying, "Action speaks louder than words." We must remember this when communicating. Realizing the communicative power of *action,* one so-called "supervisor" abruptly told his men, "Don't do as I do—do as I *say.*"

Whenever considering means of conveying information, the communicator should always consider the strengths and weaknesses of methods available. Above all, he should *always put himself in the place of the recipient.* This is extremely important in all communications—regardless of method.

Next Month—
Plant Communications

THEY ALWAYS SAID "OH!"

by Herbert J. Weber

Sometime ago I was in a foundry making a study of a welding-fume problem. It was necessary for me to make certain observations, measurements, and calculations which I entered in my notebook.

Management was concerned that my activity would arouse suspicion on the part of the employees, and that they would get the impression that there was an iminent danger to their health.

Actually management was trying to improve the ventilation system which was doing a fairly good job anyway.

I was therefore given strict instructions to evade any questions put to me by the workmen.

Later, when I completed my study, the boss inquired, "What did you tell them when they asked what you were doing?" "I told them," I said, "that I was trying to determine the atmospheric concentration of sub-micron particulates, and whether or not these would be phagocytosed on inspiration."

He then asked me how they reacted to that explanation and I replied, "They always said 'Oh'!"

This points out a weakness in human nature. Most of us hesitate to question further when we don't understand for fear of disclosing our ignorance.

It also points out another fact. We can often talk over the heads of our men either deliberately or unintentionally.

I can tell you right now that these two facts have been the reason for many accidents.

As a case in point, I once heard a cleaning room foreman instructing a new man in the safe way to test, mount, and use a grinding wheel.

I could tell that the foreman was displaying his knowledge for my benefit and that the new man didn't understand. Yet when the foreman asked him if he did, he said he did.

Later, on cross examination, I found that the new man didn't have the slightest conception of the safety practices required for his job. Had that man been put to work without proper safety instruction, I am convinced that he would have seriously injured himself or others!

Here's another case. In a large foundry laboratory a young man employed to clean glassware and otherwise assist the chemists, was told when cleaning glassware he was never to mix an oxidizing agent with a reducing agent. The young man didn't know one from another and was afraid to ask.

One day he poured perchloric acid into a beaker of boiling alcohol to clean the beaker. The resulting explosion caused severe burns on his face and neck.

Kipling once wrote:
"The Colonel's Lady
And Judy O'Grady
Are sisters under the skin."

And that holds for you too. Your man is no different than you. Just as you might have been afraid to ask your boss, your man is probably afraid to ask you.

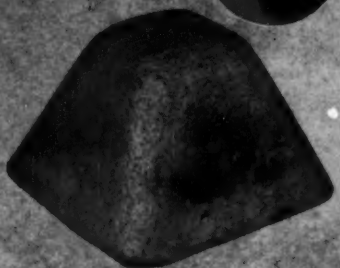
For example, the next time you tell your man that the tibial abductors should be used as well as the brachial flexors when lifting, if damage to the intervertebral disc is to be avoided, he will likely say, "OH!"

But if you are to prevent back injuries, for example, describe in simple clear language how to lift safely and explain what happens when the leg muscles are not used in lifting.

Then demonstrate the proper technique and have your man go through the act until you're sure he knows.

I know of a man who was overcome with carbon tetrachloride vapors. The warning label on the container read: "Use with *adequate* ventilation." Nobody told him how much was adequate.

If you want to stop accidents in your plant, make sure your men don't say "OH!"



Foundrymen Quick to Adopt New Ductile Iron Test

Here are direct results of production experience by five foundries in adapting an AFS quality control test. The original report, "Microscopic Test Coupons," appeared in the November, '60 issue of MODERN CASTINGS. All cooperating foundries have adopted the test as a standard procedure.

With special assistance from the following contributors:

D. F. De Clark, C. D. Berry, and M. J. O'Brien
Grede Foundries, Inc.
Milwaukee, Wis.

P. H. Dirom, Jr.
Lynchburg Foundry Co.
Lynchburg, Va.

Ted Haines
Woodruff & Edwards, Inc.
Elgin, Ill.

W. M. Spear
Worthington Corp.
Harrison, N. J.

G. F. Thomas and
E. Welander
Deere & Co.
Moline, Ill.

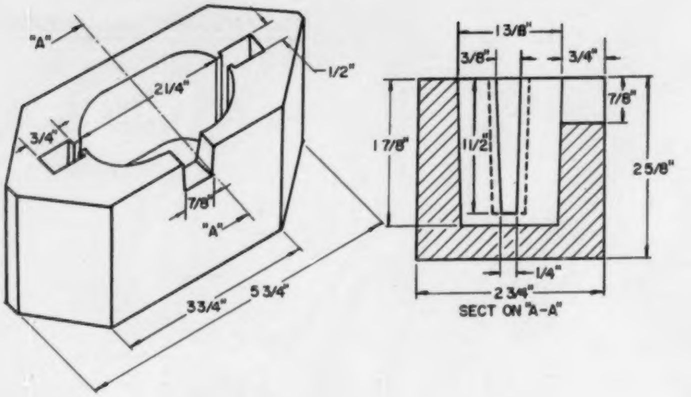
DUCTILE IRON FOUNDRIES are already profiting from new quality control technology recently announced in MODERN CASTINGS.

"Microscopic Test Coupons—A Report of AFS Ductile Iron Research Committee, 12-K" was published in the November, 1960, issue. As a striking demonstration of the speed with which new technology moves into production practices, MODERN CASTINGS asked five prominent foundrymen to comment on their use of the new test.

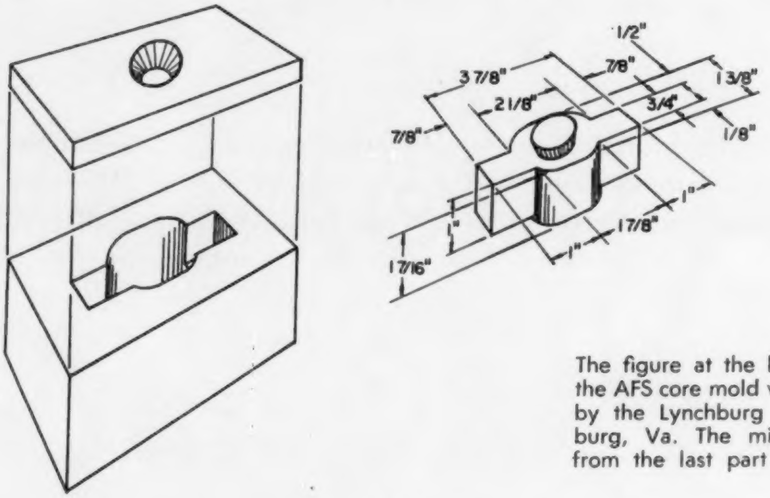
Adapting the technique set forth in the report to their own operations, the cooperating foundrymen expressed unanimous success in achieving their control goals.

To produce consistent quality ductile iron castings, foundrymen learned that they must know the effectiveness of their magnesium inoculation. Many castings were scrapped because either too much or too little nodulization resulted from the inoculation treatment.

A microscopic examination of a solidified sample proved to be the only reliable indication of the graphite structure to be expected in the castings. So the AFS Ductile Iron Research Committee set about to establish a test that



This is the recommended test coupon for microscopic examination of ductile iron as suggested by the AFS Ductile Iron Research Committee (Page 118, November '60 issue).



The figure at the left is a modification of the AFS core mold which is now being used by the Lynchburg Foundry Co. in Lynchburg, Va. The microspecimen is poured from the last part of each ladle of iron.

would be fast, economical and reliable. A test specimen was devised. Plans for the core mold are shown above.

The five foundries contributing to this report have all adopted this test as standard procedure for evaluating each ladle of treated iron. Heretofore, they have always had to make one of two choices. Either add so much magnesium alloy that there would be no possibility of failing to obtain spheroidal graphite, or limit the magnesium addition and apply a quick test to elminate the occasional ladle with an inadequate magnesium content.

The first solution is inadvisable because excessive magnesium additions contribute to pinholing, poor surface, dirty castings, and shrinkage. The latter practice becomes preferable now with the aid of the new microscopic test.

The ultimate goal is to achieve optimum properties by having all the graphite in the spheroidal or nodular form. To do this, each ladle of metal must be sampled after inoculation with magnesium and silicon.

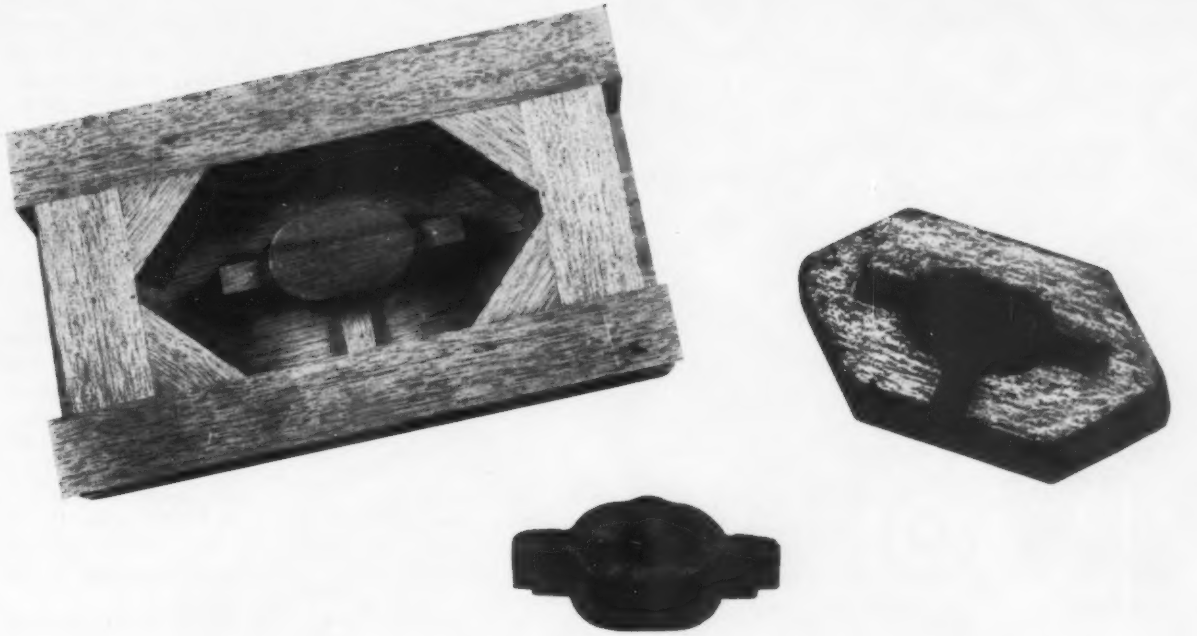
To observe the possible influence of "magnesium fade", the test coupons should be poured from the last metal available from the treated batch.

The center section of each pouring coupon can be coded with a heat number and be used for routine chemical analysis.

Once the sample is poured, speed is of the essence. Microscopic examination can be completed in 3 to 10 minutes. Several of the reporting foundries found it practical to install a small metallography laboratory in the melting department. As soon as the sample solidifies, it is water quenched, and the lugs are knocked off or removed with a cut-off wheel. Lugs are placed in properly identified envelopes and delivered to the inspection station.

At Lynchburg Foundry the lugs are polished on a wet grinder and then on a wet disc grinder. This permits rapid polishing with a series of grades of abrasives ranging from 120 grit to 600 grit. Final polishing is performed on a wet polishing wheel using a fine abrasive powder.

Worthington Corp. gains time by using just a grinding wheel, three grades of abrasive paper, and a 0-5 micron diamond polish.



This core box, baked sand core mold, and the test coupon is used by Grede Foundries, Inc. Milwaukee, Wis., one of the five foundries participating in this report. This standard AFS Micro coupon is used regularly to evaluate the graphite configuration of all ductile iron made at Grede.

The specimen is now ready for microscopic examination of the graphite appearance at 100X. Some foundries etch the specimen with 2% nital so they can observe the matrix for evidence of undesirable carbides (cementite). If the nodule appearance is satisfactory the ladle is released for pouring. If not, the metal can be modified, re-processed, or diverted to other uses. New instructions for charging, alloying or treating are issued to the cupola foreman when microstructure varies from the standard.

Some foundries proceed with pouring while the test is being made. Adjustments then are made in the next batch. If the batch already poured is too far out of specification the castings are isolated for possible scrapping.

Hundreds of comparisons have been made between microstructures in coupons and castings with excellent agreement found.

Deere & Co. follows this procedure in their ductile iron foundry: "All treatment ladles are numbered consecutively and the molds are identified according to ladle number. No molds are dumped until a metallurgical observer has examined the test coupon and approved the ladle. The inspection is completed before the castings are cool enough to shake out.

"Should the metallurgical observer find in excess of 10 per cent vermicular graphite in the test coupon, the foundry metallurgist is informed. Based on mechanical properties data, it has been demonstrated that up to 10 per cent vermicular graphite will usually permit meeting our specifications. If the metallurgist concurs with the observation, all castings poured from the treatment ladle are segregated and held for disposition. Further inspection is then made of either castings or runner bars from the castings to determine whether or not the castings are acceptable.

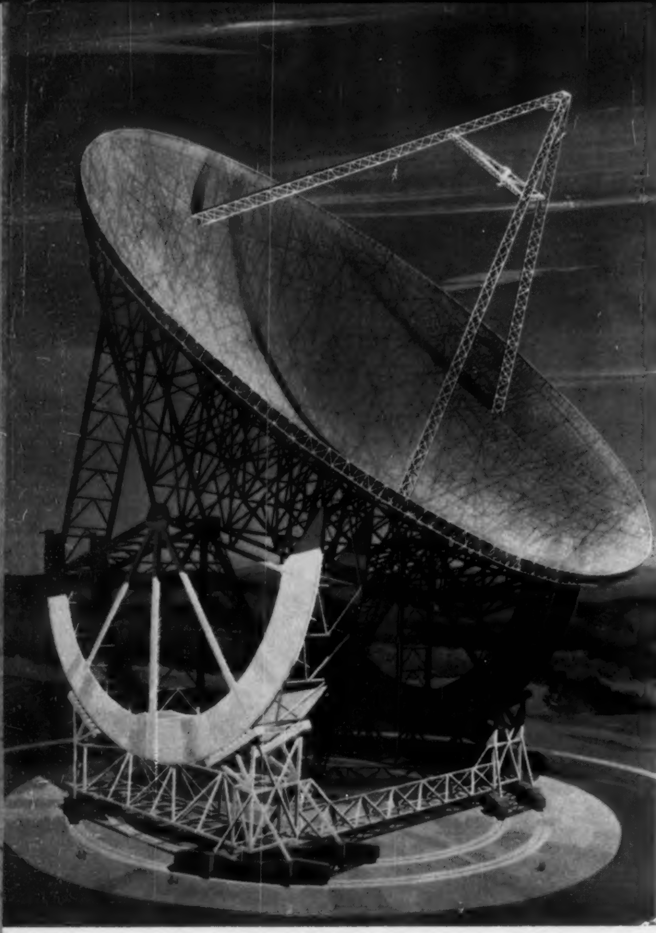
"It has been occasionally observed that the castings will be acceptable when the test coupon indicates a marginal or unsatisfactory condition. This is possible because the test coupon represents the very last iron poured and may not be representative of the iron poured into the molds. Being the last iron poured, it may occasionally contain slag or dross which also can affect the appraisal of the graphite."

Several foundries also use the micro-test coupon for carbon control during melting, evaluation of carbon flotation in castings, and adjustment and evaluation of heat treat practices.

At the end of five months experience, Woodruff & Edwards, Inc., endorsed the test with these comments:

"1. The nodular graphite structure in this test lug correlates with that in the casting.
2. Carbon flotation, when present, is quite distinguishable in the lug and is generally found to be present in the casting.
3. A below normal graphite structure is discernable in the lug and correlates with the casting poured.
4. The sample can be readily transported to any part of the foundry because of its size.
5. It is economical to produce."

The unanimous success of these five ductile iron foundries demonstrates the importance of putting new technology into action in the foundry. Each ductile iron foundry in the country should include this test as a part of their quality control program.



When completed, this radiotelescope will revolve on a central pintle bearing—the largest ever built.

COVER STORY

Casting a Shaft for the 'Big Ear'

The Navy's new radiotelescope is expected to probe over 38 billion light years into outer space. It utilizes a monster pintle shaft—largest of its kind ever cast by General Steel Castings Corp.

A 250,000 POUND STEEL pintle shaft will provide the axis of rotation for the world's largest radiotelescope. Now under construction by the U. S. Naval Research Laboratory at Sugar Grove, West Virginia, the giant reflector, or "dish", will be 600 feet in diameter and have an area exceeding 7 acres.

This 30,000 ton structure is designed to revolve on a central pintle bearing—the largest ever built. The pintle shaft had a rough casting weight of 250,825 pounds, a height of 15 feet 4-1/2 inches, outside diameter of 10 feet and a 7 foot inside diameter.

The responsibility for making this important casting was awarded to General Steel Castings Corp., Eddystone, Pa. Besides the shaft, General Steel Castings also cast two half bases weighing about 181,000 pounds each, and two half bearing housings running close to 131,500 pounds each. These four castings were made to ASTM Specification A 27-58, Grade 65-35, and were radiographed.

Because of the record-breaking nature of this unusual casting job, MODERN CASTINGS asked Clyde Jenni, Director of Research & Chief Metallurgist for General Steel Castings Corp., to relate a few of the details involved in casting the pintle shaft:

"The pintle shaft, weighing over 250,000 pounds, was the largest casting ever poured in our Eddystone Foundry. This casting was made to ASTM Specification A 356-58T, Grade 3. Production ran 19 weeks.

A three-piece pattern was built for slinger molding. The main core was made in four pieces. The two lower cores were bolted down while the two upper cores were held with a binder.

Our 14 foot diameter round flask equipment consisted of a 10 foot high drag with a 10-1/2 foot cope. A gate extension was required to obtain suitable pouring. Molding was done in a 11-1/2 foot deep pit.

The molds were made using Jersey silica base sand and dried for 72 hours at 650 F. They were then rewashed and dried 10 additional hours at 650 F.

The casting was poured using three open hearth heats. The first two heats were poured simultaneously and formed the base metal in the casting. Two bottom pour ladles, each having a capacity of 173,250 pounds with two 4 inch nozzles, were used. Feeding was staggered so metal entered the mold at various levels. The third heat, about 30,000 pounds, was poured four hours later, touching up the heads.

Approximately eight hours after the last hot metal was poured, 1200 pounds of exothermic material were used. Shakeout followed two weeks after pouring. Thermocouples were placed throughout the mold to insure temperatures below 850 F before shakeout. The casting cooled to about 2000 F fairly soon but thereafter dropped only 100 F in each 24-hour period.

The total estimated pouring weight was approximately 360,000 pounds. Yield was about 65 per cent. To insure proper quality standards, the casting was subjected to magnetic particle inspection in our shop."

Capable of reaching 38 billion light years (one light year equals 6 trillion miles) into space this radiotelescope will be used in basic research.

The metalcasting industry can take pride in the steel castings that are performing vital functions as this "big ear" probes the mysteries of the universe.

The massive pintle shaft (15 feet high and 10 feet wide) was transported by flat car to a rail head 50 miles from the Sugar Grove, W. Va. site of the radiotelescope. It was then carried over mountain roads on a special wide-bed truck brought in from Knoxville, Tenn. The shaft was mounted (pictured above) on a giant shaft support base (24 feet in diameter) also made by General Steel Castings Corp.

More Incentives for Workers—More Profit for Foundries

One road to lower labor costs is better wage incentive administration. Whether production volume is high or low, foundrymen seeking profit improvement will find an adequate plan pays dividends.

BY JOHN R. WALLEY
Adams-Steele, Inc.
Chicago, Ill.

IF YOU HAVE A WAGE incentive plan and it has not lowered your castings costs during prosperous as well as adverse times, there is something wrong with the system.

Here's a case in point. A foundry installed an incentive plan to increase output of workers who inspected, welded, and repaired defective steel castings. To make this plan work, it was necessary to add a timekeeper and an extra inspector. Potential savings indicated that expense of the added personnel would be quickly offset by substantially lower labor cost.

However, within a few weeks it was found that the plan not only increased direct labor rates from \$1.85 to \$4.90 per hour, but it cut down on the number of castings being repaired. The plan had been incorrectly established and the company was forced to withdraw it within 60 days after installation.

Few wage incentive plans are so poorly constructed that costs rise quickly and output falls disastrously. However, it has happened and will continue to do so where the wrong yardsticks are used or inadequate provision is made for proper administration of the plan.

Today, it is necessary that every division of the foundry operate effectively to assure survival of the business. In foundries using wage incentive plans, much credit or blame for profitable operations can be traced to administration of compensation systems.

There are five simple checks that can be made to review functioning of an incentive plan to determine if its contribution to profits should be considered satisfactory or not. Also, through this same approach, the spotlight will be thrown on any problem area which may or may not be known. The five checks are as follows:

1. Comparison of foundry operating efficiency over the period of years during which the present incentive plan has been in effect.
2. An analysis of output of workers in the same occupation to determine whether or not an arbitrary ceiling has been set to hold down castings production.
3. Comparison of differences in rate setting abilities of Industrial Engineers by establishing output required for a satisfactory days work.
4. A review of the Daily Report of Operators Performance to determine overall effectiveness of applying work measurement standards in each operating department.
5. A comparison of the number of engineers assigned to operate the incentive plan in your foundry with other firms in the industry.

Making such a preliminary investigation of the effectiveness of an incentive plan can be undertaken by the plant Industrial Engineer. Or, management in some foundries prefer to call in consultants to make this study so as to obtain an unbiased report.

Creeping Changes

The first check suggested is to compare operating efficiency of the foundry over a period of years. The period studied should be that during which the incentive plan has been in effect.

Shown in Figure 1 is the method used by management of one steel foundry to analyze operating efficiency where performance standards were based upon standard hours. One hundred per cent of standard represented a day's work to earn the basic hourly rate paid for each occupation. Expected performance was to be within 120 to 130 per cent of standard.

When the incentive plan was

first established, difficulty was encountered in getting the men to meet standard as indicated by reports of the years 1953 and 1954. Then, in the latter years of 1958 and 1959 they were exceeding it by too great a margin. The records reveal that performance standards in use were no longer correctly measuring work done. Profits were off in this foundry which further substantiated these findings.

Even in well administered plans, many Industrial Engineers recognize that there may be as much as five per cent decrease per year in productivity. This decrease in productivity is due to what is known as *creeping changes.* These are the unreported method, material, and equipment changes introduced by workers, foremen and others. When such changes are not caught by the Industrial Engineers, the worker increases his earnings at company expense.

Profitable foundry operation demands that method changes be reflected in savings to the company. This means revising performance standards quickly after introduction of improvements.

Ceiling on Earnings

At installation of an incentive plan, some foundry managers ask for a ceiling on earnings. The ceiling is felt to be necessary in order to protect the company from runaway incentive earnings.

But, a ceiling on incentive earnings has never been known to work satisfactorily for any length of time. If Industrial Engineers are setting performance standards, the ceiling encourages sloppy work measurement. This means that standards will be set at a point where the engineer will have fewest complaints from the worker. Then the incentive plan merely becomes a glorified method of wage payment.

On the other hand, when performance standards have been loosely established or creeping changes have permitted the output requirements to be reached easily, workers will often set an arbitrary ceiling on earnings of their own accord. The ceiling established will be at an earnings figure which the worker believes management will pay without attempting to revise standards.

Figure 2 shows a comparison of

Figure 1—A comparison of foundry operating efficiency over the period of years during which an incentive plan had been in effect.

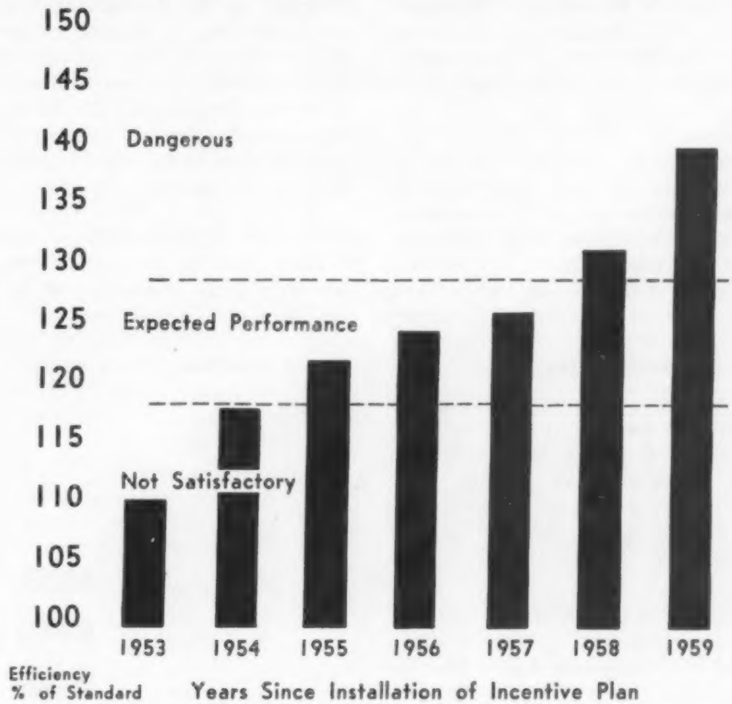
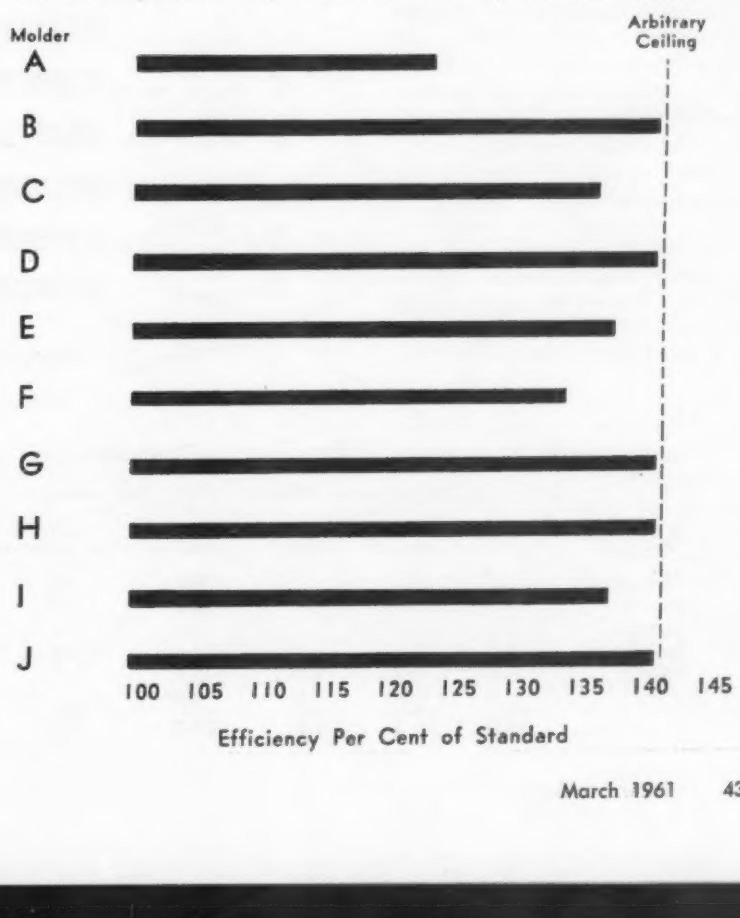


Figure 2—Graphic analysis showing how it is possible that workers within a department may have set an arbitrary ceiling on output.



the efficiency per cent of standard reported by ten floor molders over a period of 30 work days. Management of the foundry, whose figures are reported here, felt that something was wrong in the Floor Molding department but could not isolate the problem. Through this simple check, and by a closer examination of work performed by the men on the job, it was determined that they had arbitrarily set their own ceiling or pegged production at the level of 140 per cent of standard.

Need for Training

Setting of performance standards whether through use of stopwatch time study or by the application of predetermined motion time standards will never eliminate the use of judgment on the part of Industrial Engineers working in a foundry.

In Figure 3, you will see the average efficiency percent of standard in departments where four Industrial Engineers were setting performance standards. The engineers are identified as A, B, C, and D.

Engineer A is shown to be a tight rater. Workers in the Sandmixing, Coremaking and Coreblowing departments always have trouble earning incentive pay. When it is earned, they think it is an accident. Result is frequent grievances, low productivity, and general dissatisfaction.

On the other hand, Engineer C is known as a loose rater. In the molding departments, where he establishes the work pace, men have longer coffee breaks, more time out for eating sandwiches and generally take home the most envied pay checks in the foundry. However, the departmental foreman always has difficulty in getting out enough molds to meet schedules.

Profits in the foundry are dependent, to some degree, on getting a fair days work out of each man. Industrial Engineers must be given training periodically in performance leveling if a consistent day's work is to be asked throughout the foundry.

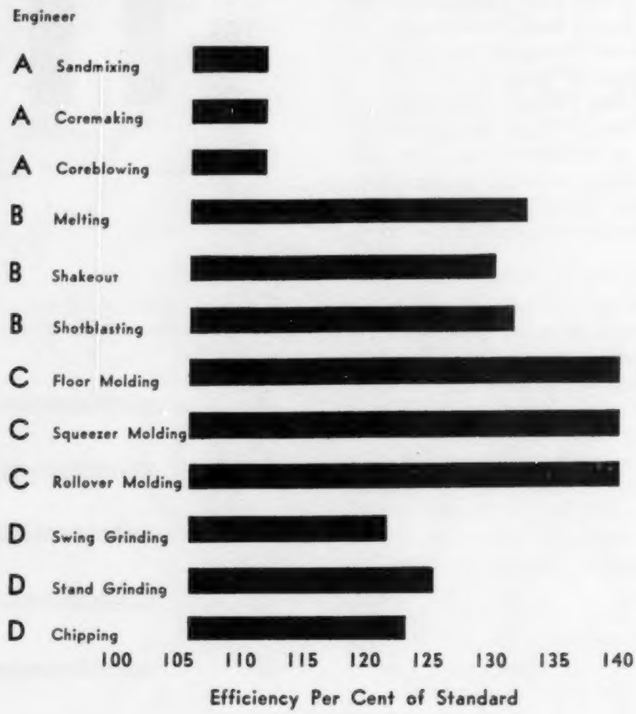
Daily Efficiency Report

Long term benefits from wage incentive plans are obtained easiest through diligent scrutiny of short term records. One of these records is called a Daily Report of Operators Performance. In this report may be found all essential information needed to tell how successfully the principal elements of a wage incentive plan are meshing together.

Figure 4 is a Daily Report of Operators Performance showing day by day results of work measurement in a Grinding department. Upon review of this daily report, a number of indicators show trends which are dangerous to the profit position of the company. These dangers may be described as follows:

1. As much as 19.2 hours or 40

Figure 3—Differences in rating ability by Industrial Engineers can result in varying demand's for a day's work.



Daily Report of Operator's Performance

Grinding Department, Feb. 10, 1961 (Units-Hours)

Name	Worked	Not Measured	Lost Because of Delays	Measured	Earned on Measured Work	Efficiency % of Standard
A. R. Thompson	8.0	4.0	.9	4.1	.4	110
J. R. Jones	8.0	5.0	.8	2.2	.8	136
P. N. Lynch	8.0	3.8	1.2	3.0	1.2	140
P. S. Smith	8.0	2.1	.3	5.6	.6	110
C. L. Nisely	8.0	1.9	.7	5.4	1.8	133
R. H. Frey	8.0	2.4	1.9	3.7	1.2	148
	48.0	19.2	5.8	24.0	6.0	125

Figure 4—Day-by-day results of work measurement in a department where labor standards have been applied. Periodic review will reveal trends which affect profit.

per cent of the hours available for work were not measured.

2. There were 5.8 hours or slightly more than 12 per cent of hours available lost because of delays.

3. Only 24 hours or 50 per cent of hours available were worked on standard. This is considered a very low percentage of coverage.

4. Finally, even though the department average efficiency per cent of standard is 125, four out of six grinders show efficiencies higher than 130 which may mean incorrect measurement or standards.

The Daily Report of Operators' Performance should be considered one of the most important records maintained regularly for review by the incentive plan administrator. Only by watching this record can the administrator have his finger on the pulse of the incentive plan and quickly note minor fluctuations which tell of troubles ahead.

Finally, it is well known that adequate manpower must be available to do any job well. A soundly administered wage incentive plan requires not only competent men, but also an adequate number.

A hard and fast rule as to the exact number of men required to carry out various duties related to maintenance of the incentive plan would be difficult to establish. There is no uniformity among foundry managers as to what they expect from their Industrial Engineering department. Some managers want rate setting only. Other managers want methods improvement, cost estimating, union contract negotiation, and a host of other related duties.

Manpower Requirements

Here is a rule-of-thumb guide for determining the minimum number of engineers required to maintain an incentive plan. The variables that must be considered are the number of production employees working within a given foundry and the types of wage incentive plans which are to be maintained.

Figure 5, illustrates one way to compare manpower requirements for maintaining a wage incentive plan, considering the two variables described above. For example, where individual standards are to be established on operations such as molding, coremaking, and cleaning room operations, it is shown that a foundry having 200 works employees would need at least three engineers. On the other hand, a foundry with 1000 works employees would probably require at least ten engineers. Also, the other lines indicate that fewer engineers are necessary as more use is made of group incentive plans. Standards for group plans are calculated for a large number of employees through use of historical records.

Group incentive plans require less engineering manpower, but this method of compensation seldom achieves output per man hour comparable to that of individual piecework. The payroll cost of engineering help to set individual work standards is insignificant compared to vastly increased labor savings possible.

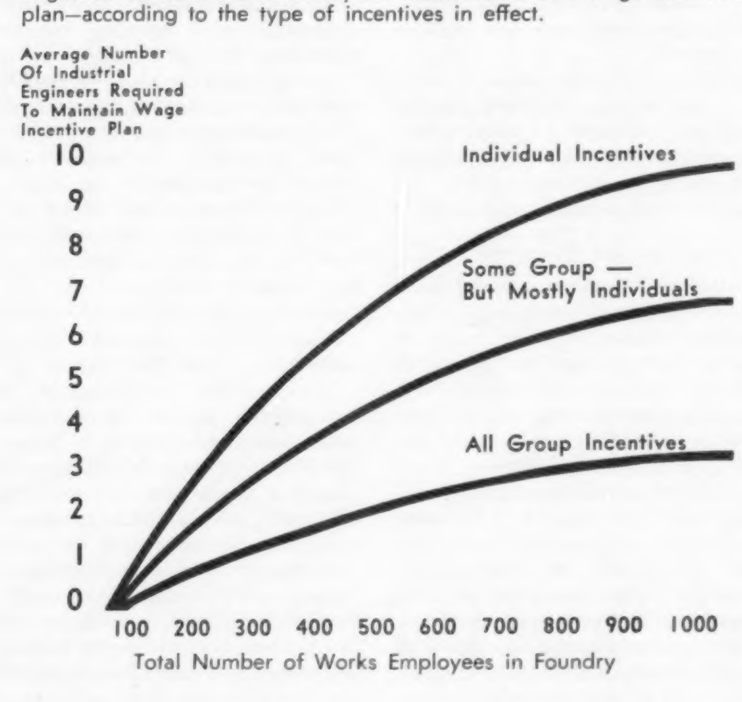
Use Standard Data

One of the most satisfactory ways to obtain a high degree of incentive coverage with minimum engineering cost in a foundry is through use of standard elemental data. Such data results from the accumulation of many time studies and converting them into easy-to-apply tables. Lower skilled men can be used to apply standard elemental data, with resultant drop in payroll.

Properly trained Industrial Engineering staffs contribute handsomely to foundry profits through method improvements, correct work measurement, and many other ways. If there is some doubt as to whether or not the Industrial Engineering group is properly staffed, it is usually wise to add competent men any time they can be obtained.

Correction of defects in an incentive plan cannot be done overnight. Nor can a generalized approach be described to correct the situation. Every system is different, even among foundries within the same company. However, by use of the analytical methods described, plus others available and peculiar to specific foundries, problem areas can be isolated for corrective action. Such careful analysis is necessary to plug profit leaks possible through payment of unearned incentive wages.

Figure 5—A comparative check showing average number of Industrial Engineers found to be necessary for maintenance of a wage incentive plan—according to the type of incentives in effect.



New Applications Spur Malleable Iron Industry

1. *Pearlitic malleable iron is currently pacing the industry with an 800 per cent growth in the past 15 years.*

2. *Stress analysis studies have lead to engineered malleable castings with maximum performance at minimum weight and reduced cost.*

3. *Modern ordnance applications offer new opportunities for castings in shells, rockets and atomic weapons.*

4. *A nation-wide advertising program is alerting potential users to the great number of new qualities and applications for malleable iron.*

Reported by Jack H. Schaum

Paced by a Rapid Growth in the use of pearlitic malleable, the malleable iron industry is fending off competition with vigorous advertising, hardselling, and new technology.

From a level of 27,500 tons in 1945, sales of pearlitic malleable iron castings have skyrocketed to over 200,000 tons in 1960. This phenomenal 800 per cent growth can be attributed to recognition on the part of buyers that pearlitic malleable provides *more strength per unit cost than any other cast material produced in this country!*

The automotive industry has been particularly alert to the advantages of pearlitic malleable. Components currently being made in this material include: crankshafts, camshafts, rocker arms, crankshaft sprockets, transmission gear, transmission pistons, diesel pistons, and universal joint yokes. Industry acceptance of this reliable engineering material has been based on its excellent machinability, hardenability by heat treatment, wear resistance, and design flexibility.

Pearlitic materials achieve yield strengths as high as 90,000 psi. In fact they are endowed with a superior ratio of yield strength to tensile strength which exceeds that of steel at a comparable tensile level.

Technology for Progress

Modern Castings queried key leaders of the malleable iron industry on important issues of the times. In response to questions about technical developments, these men were unanimous in their praises of technical progress that has kept them competitive.

The preceding comments have emphasized the impact of the new technology of pearlitic malleable iron. Much of the success with pearlitic should be attributed to improved heat-treating techniques. Furnaces have been re-designed to use electricity, gas, or oil and move the castings continuously through various heating zones. As a result annealing cycles now only last 36 to 48 hours instead of the previous 10 to 12 days needed for batch treating in coal-fired furnaces. Furnace atmospheres are now synthesized to protect the surfaces of castings from oxidation.

The chemistry of the metal has also been modified to speed first and second stage graphitization. For instance addition of the element boron improves annealability.

Elmer Braun's comments reflect industry's respect for technology:

"As a result of technological advancements, we are in a better position than ever before to exploit the fact that the casting process is one of the lowest cost methods of shaping metals. Better sand control, new metallurgical controls, and improved mold and core machines have contributed materially to the significant progress made during recent years. In the field of new foundry control mediums, the use of radioactive isotopes appears

This exhibit created by the Malleable Founders Society clearly illustrates that there are now more than 40 malleable iron parts used in the construction of a typical automobile today.

to have considerable promise. We are now using a form of nuclear energy to measure the moisture content of sand, and have an active isotope development program underway aimed at providing better metallurgical controls for both ferrous and non-ferrous products."

Greater precision in the "as-cast" dimensions of malleable castings can be attributed to such new developments as shell molding and core making, CO_2 process, furan cores, and epoxy resin patterns. These new practices permit better products at lower cost.

Guaranteed casting integrity—a must for product reliability—can be assured by such new quality control tools as ultrasonics, magnetic particle, and radiography. The latter has also been used to help design gating and risering systems.

The new science of stress analysis used in designing castings has received more application by producers of malleable iron castings than any other segment of the industry. By studying the static and dynamic distribution of stresses in a component it can be engineered to yield maximum performance at minimum weight and cost.

The malleable iron industry has benefited from technical assistance by the American Foundrymen's Society and the Malleable Founders Society. The AFS has a Malleable Iron Division with 10 committee members working on a number of research projects. One program is aimed at casting heavier sections than currently feasible. The Malleable Founders Society has just published a new reference handbook—"Malleable Iron Castings"—and already distributed 12,000 copies. This book is aimed at providing technical guidance to both the producers and consumers.

Yesterday's technology is the platform for tomorrow's progress. One malleable foundry expects to announce in 1961 a new metallurgical approach to the manufacture of malleable iron. They hope to introduce a new malleable iron that can be produced at the same cost as standard SAE-35018 grade; but which will have minimum physical properties close to 40 per cent above those specified for this grade. This will give design engineers a material to work with that is far superior to anything they now have.

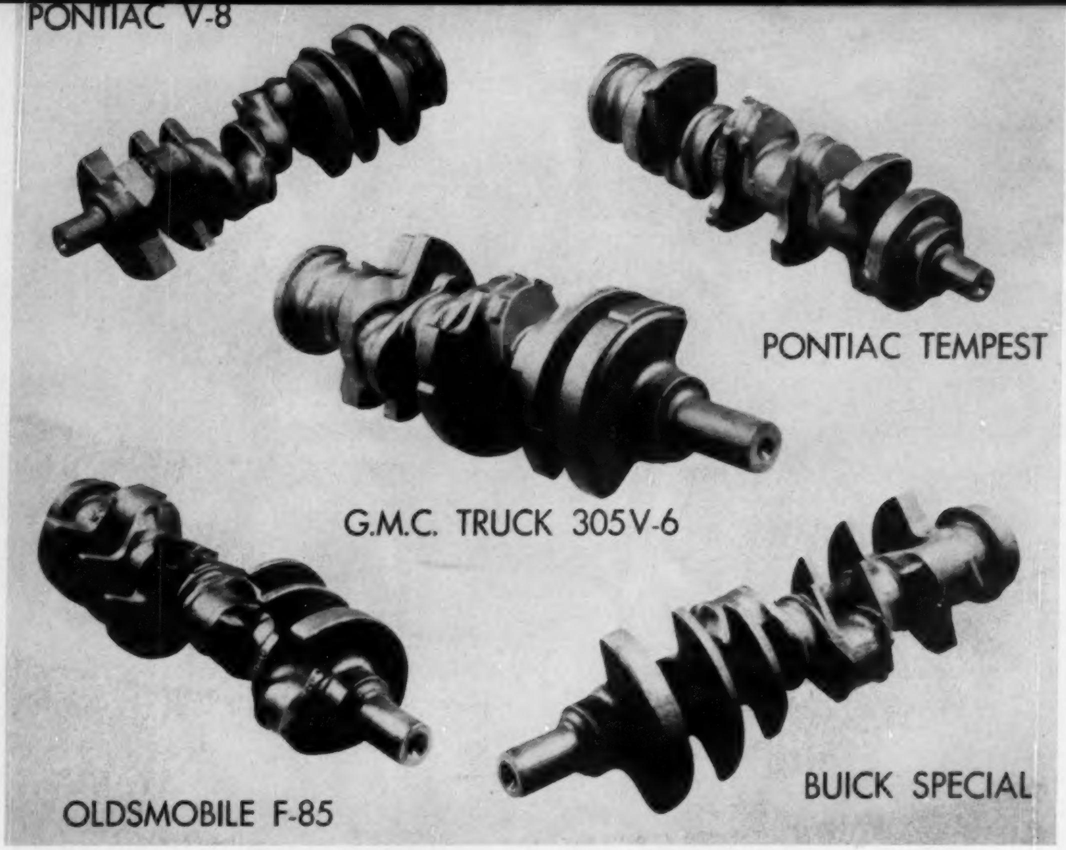
Blending Malleable and Gray

Another producer is blending molten malleable iron and gray iron to produce an economical material with very fine grain structure, relatively free machineability, and extremely high impact strength.

A new German process nitrides the surface of pearlitic castings and makes them competitive with certain forged products.

The crystal ball of technology foresees malleable foundries converting to electric furnace melting and heat treating continuously in a fluidized bed of hot metallic particles.

Malleable industry leaders are



Five malleable iron automotive crankshafts now being used by manufacturers. Two are used in compact cars, two in standard models and one is used in a truck.

constantly scanning the horizon for new applications. Because of the enthusiastic acceptance of pearlitic malleable by the automotive industry, deeper penetration is being sought. There is still more crankshaft business that can be converted from steel forgings.

Small engine crankshafts for lawn mowers, air conditioners, etc., are starting to be made in pearlitic malleable. Automatic pin-setters for bowling alleys and boat trailer components are growth industries that are sold on using malleable.

Recent research has demonstrated the effective service of malleable iron castings at elevated temperatures in the range of 800-1000 F. The proof of these properties should open new market opportunities for sales to furnace builders.

Permanent mold casting of malleable iron should be a "natural" since fast cooling favors formation of white iron. One foundry is successfully casting bolts in permanent molds.

Current research and development programs involve use of pearlitic malleable irons in atomic weapons and boosted rockets. A detonating spike used on the nose end of an antitank projectile is currently being produced in a pearlitic malleable iron.

The improved effectiveness of pearlitic malleable artillery shells has attracted the attention of other NATO countries, with the result that Canada, France and West Germany have successfully test fired pearlitic shells.

Pearlitic malleable is no stranger in the weapon industries. In World War II over 20 million gun parts were cast in this material.

A breakthrough in a new ordnance use for pearlitic malleable is expected to be announced within the next month. MODERN CASTINGS will carry this important news!

Ductile Iron Competition

Most of the malleable foundrymen surveyed by MODERN CASTINGS were relatively unconcerned about ductile iron as a serious competitive threat. Parts with too large a cross-section to be made in malleable are often made in ductile. But this represents no loss.

Where the part is suited to malleable, the producers feel that they can always make it cheaper.

Norman Amrein believes "that the competitive threat of ductile iron is stimulating the malleable industry to pursue new technology which will, within the next five years, make us competitively stronger than at any time in our history."

Malleable producers are taking a serious look at ductile iron production as a second material to broaden and diversify their markets. Malleable foundries are better equipped and trained to produce ductile iron than are most gray iron foundries. The same heat-treating furnaces used in malleablizing iron can also be used for treating ductile iron. Several malleable foundries have already taken the step into commercial ductile iron production.

Malleable industry leaders are giving a lot of thought to ways of improving their competitive position today. They all recognize the terrific selling job that must be done every step of the way. Actually the selling technique most needed is technical education. Customers and prospects need to be made familiar with the inherent advantages of malleable products, processes, and capabilities.

Work with Designers

Technical sales engineers must get their foot in the door early by sitting down and working with design engineers. In this way malleable castings can be built into the original designs.

By providing stress analysis service to customers you can help design the components so cast malleable provides the ultimate.

One of the pioneers in this stress analysis service is Superior Steel & Malleable Castings Co. Their President R. L. Gilmore emphasizes: "Our customers are more interested in the service that our malleable iron castings render than they are in the castings themselves. If the casting will do the job it was designed to do, efficiently and economically, then it is rendering a useful service. If it doesn't do this, then it is economically unsound regardless of the cost of the part."

With this approach new market opportunities will be recognized in the form of many conversions from weldments, forgings, stampings, and fabrications.

A marketing program of national scope is currently underway in the form of technical magazine advertising. Sponsored by 45 malleable foundries, the Malleable Castings Council is now in its third year with $200,000 allocated for national advertising in 10 major metalworking journals and 24 college engineering magazines. The college program is aimed at influencing future potential users. Each ad demonstrates important industrial applications served by malleable.

Cost reduction always stands high on any manufacturer's list of improvements needed. And the malleable industry is no exception. Mechanization and modernization are needed to reduce man-hours per ton of castings and ultimate labor costs. Along this line of thinking we have this statement by Malcolm Baldrige:

"I think the industry as a whole must face the fact that there is far too much capacity. A good deal of this excess capacity is in antiquated and outmoded plants. The industry is at a point where high cost operations should be shut down and consolidations affected if necessary. In our company we have improved our position considerable by shutting down facilities when warranted and by buying or developing proprietary products which enable us to make full use of our facilities."

Deliver a Finished Casting

Malleable foundries can improve their competitive position by delivering a finished casting ready to assemble. Advanced foundry techniques permit parts to be cast-to-size. Straightening, coining, and punching equipment can be used to complete the job.

The new look in malleable iron has developed from efforts on many fronts.

T. T. Lloyd summarizes the progress with these words: "Malleable foundrymen have become increasingly aware of the need for supplying improved and expanded technical services in addition to supplying castings. This is particularly true in the areas of materials specification and design.

"The result has been better integration of effort by sales, metallurgical, and engineering departments. Largely through the impetus provided by the Foundry Educational Foundation and more recently by the American Foundrymen's Society Training and Research Institute, the technical competence of the industry and, in turn, the quality of its services are at an all-time high.

"It is now necessary for industry at large to be told about the malleable industry, what it produces, and, of more importance, its remarkable resurgence."

Malleable Iron—Past, Present, Future

A comprehensive look at the industry and its problems. Here is "inside" criticism coupled with sound suggestions.

by Gordon B. Mannweiler
Chief Metallurgist
Eastern Malleable Iron Co.
Naugatuck, Conn.

The malleable iron industry has enjoyed over a century and one-quarter of glorious history in America. While this enviable background is a decided asset, it has also led to complacency. Technological advances in other fields, particularly over the last two decades, have given birth to a host of new materials and processing methods.

Being innovations, such materials and methods have received widespread publicity. Also, much effort and money was spent to learn the qualities and potentialities of the new comers.

Meanwhile, the old reliable, malleable iron, lay essentially dormant. Finally, when the awakening did come, the industry found itself surrounded with keen competition on all sides—from other cast metals, fabrications, and plastics. The chief weapon for combatting competition has been pearlitic malleable iron. But it has been exploited to any appreciable extent only in recent years.

Pearlitic malleable can satisfy demands for more than double the strengths formerly available. At our plant about 20 per cent of current malleable tonnage is pearlitic malleable; approximately three-quarters of this is the high-elongation type (grade 45010).

Malleable iron was once erroneously considered to be only suitable for very light-sectioned castings. This misconception arose

THE CONTRIBUTORS

To Market Opportunities

Joseph Abusamra
President
Belcher Malleable Iron Co.
Easton, Mass.

Norman Amrhein
President
Federal Malleable Co., Inc.
Milwaukee, Wis.

Elmer E. Braun
Central Foundry Div.
General Motors Corp.
Saginaw, Mich.

Malcolm Baldridge
President
The Eastern Malleable Iron Co.
Naugatuck, Conn.

R. W. Crannell
President
Lehigh Foundries Co.
Easton, Pa.

W. M. Dalton
President
The Dalton Foundries, Inc.
Warsaw, Ind.

R. L. Gilmore
President
Superior Steel & Malleable Castings Co.
Benton Harbor, Mich.

R. W. Griswold
President & Gen. Manager
Erie Malleable Iron Co.
Erie, Pa.

T. T. Lloyd
Vice President
Albion Malleable Iron Co.
Albion, Mich.

E. J. Romans
Factory Manager
The Canton Malleable Iron Co.

E. K. Simonsen
Assistant Sales Manager
Belle City Malleable Iron Co.
Racine, Wis.

C. P. Speitel
President
Pennsylvania Malleable Iron Corp.
Lancaster, Pa.

E. J. Stockum
Vice President, R&D
The Dayton Malleable Iron Co.
Dayton, Ohio

partially because: 1) the heat treatment of whiteheart malleable iron, produced abroad, involved slow decarburization from the surface inward; and 2) mottled iron often developed in moderate sections of improperly-balanced white iron compositions.

There has been a constant trend toward better quality control. Small malleable plants once checked their metal only by visual inspection of white iron and annealed iron fractures. Now they have their own chemical laboratory and often employ an experienced foundry consultant on at least a part-time basis.

In the production foundry, long-running jobs warrant setting-up specialized control techniques, such as sonic and ultrasonic methods, magnetic hardness testing, and radioisotopic measurement of moisture in sand or cupola performance.

Equipment Is Better

Production equipment has come a long way toward achieving a better product at lower cost plus improved working conditions. For instance, shell cores can be made rapidly and accurately by relatively simple equipment. The hollow shell core assists venting and hastens collapsibility. Both of these are important in the casting of white irons, where solidification contraction is high and ductility after freezing is low.

The malleable industry still has much to do to improve its competitive position for tomorrow. Effectual promotion of the product is a must. Over the past several years considerable sums have been expended on an industry-wide basis for advertising. Such programs must be under continual and independent surveillance to guarantee that the maximum is being obtained for the advertising dollar and to assure that the message is getting across to those influential in the design and selection of materials. The publication of a malleable iron handbook last year should satisfy a long-standing need for an up-to-date reference volume.

However, there are other areas of promotion wherein the industry as a whole is weak. Personal contact through talks, informal discussions, and technical papers before schools, engineering societies, and purchasing groups has been a neglected factor in the overall promotion program of the malleable industry.

Another area exists in the lack of production and technical know-how by some elements in the sales organizations. A third soft spot is the general indifference to, and lack of, active participation in standards agencies. Internal factious or self-promoting groups or individuals can become undermining influences to industry-wide promotional efforts.

Some specific areas that seem fertile for research would include high and low temperature fatigue; microstructure versus various wear types; effect of sustained and cyclic heating on growth and properties; coatings for wear, corrosion resistance, and color; resistance to thermal shock; low-temperature tensile properties; development of an inexpensive impact test for routine testing that will give more repetitive and more quantitative results than the wedge test; evaluation of effect of temper carbon size, shape, and distribution on properties; and investigation of shrinkage versus composition.

Need Metallographic Standards

A centralized service to abstract articles appearing in the trade and technical literature pertaining to malleable iron and competitive materials would assist the industry as a whole to keep abreast of current developments. There is some need for metallographic standards for malleable iron. An acceptable white iron spectrographic standard is also extremely desireable.

Impatience and lack of faith in technical personnel have been barriers in the past to successful research. Also a frailness in communications has caused projects to falter or has prevented the foundry from reaping full benefits from research. Here the trouble may lie with the investigator in expressing himself, with management failing to understand the research findings and transmitting the information to operating personnel, or both.

In general, with the wide range of properties and the consistently uniform quality it offers to the manufacturer, the malleable castings industry should find no difficulty in bettering competition in most instances.

New Concept Reduces Casting Cleaning Costs

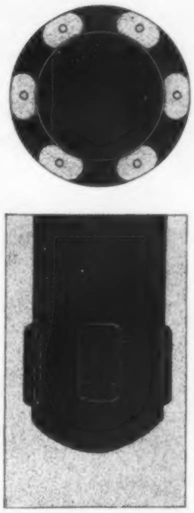


Figure 1
Innerbore Riser

Innerbore gates and risers are being used to solve the tricky problem of producing sound, clean sheave castings with high metal yield.

Success with this rigging technique on cast steel sheaves at the American Hoist & Derrick Co. foundry led to further applications.

Innerbores were adapted to a combination drum and sprocket, a jaw clutch, a bevel gear, and drum lagging. In all instances the castings are circular and symmetrical about a central axis or hub.

By Elmer Kreger
Foundry Superintendent
American Hoist & Derrick Co.
St. Paul, Minn.

The real measure of success in the initial application of innerbore risers was the overwhelming acceptance by both the inspection department and the machine shop. The resulting savings have been principally in the form of reduced cleaning costs, since the castings were sound and free of sand defects. They were, in fact, quality castings in every respect.

The initial experience with innerbores showed such definite improvement in casting quality that the added benefit of increased metal yield became a secondary consideration. However, this is still an advantage since we have experienced an average of 72 per cent yield on innerbore rigged jobs as compared to an over-all 1959 average yield of 64 per cent.

The innerbore riser shown in Figure 1 on the next page is an example of the general type used on sheave castings. On the larger sheaves, a contact must be located opposite the intersection of each spoke with the hub. Smaller sheaves, below 24 inches in diameter, can be adequately fed with three contact openings.

Either round or square contacts work equally well, but the square contact has the advantage of being easier for the cutter to remove. Therefore, it was selected as standard.

The optimum size of openings for each sheave size was determined by trial and error. Beginning with the largest size sheave, 42 inches in diameter, the optimum contact opening was established at 1-1/2 inches x 1/2 inch for the 16-inch diameter sheave. Size of hub is a prime factor in determining contact size. This means that size of opening is not directly proportional to sheave diameter.

In the upper view of Figure 1 the small circles represent vents in the core. The contact openings

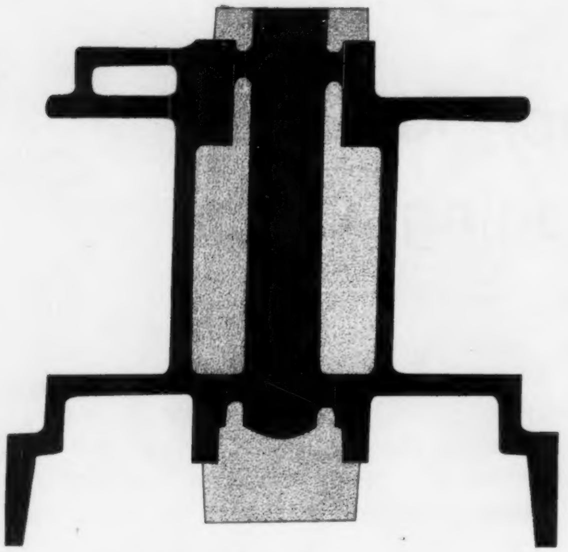


Figure 2
Drum and Sprocket

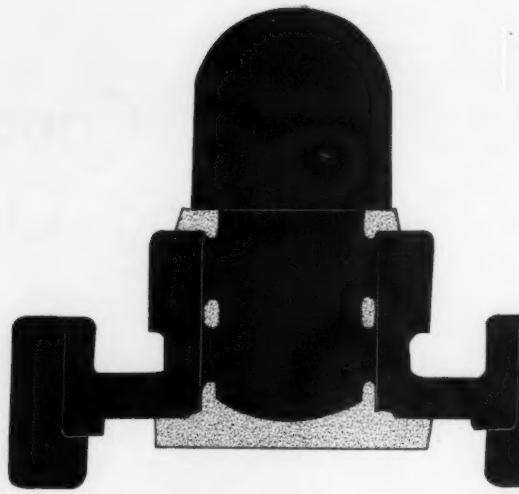
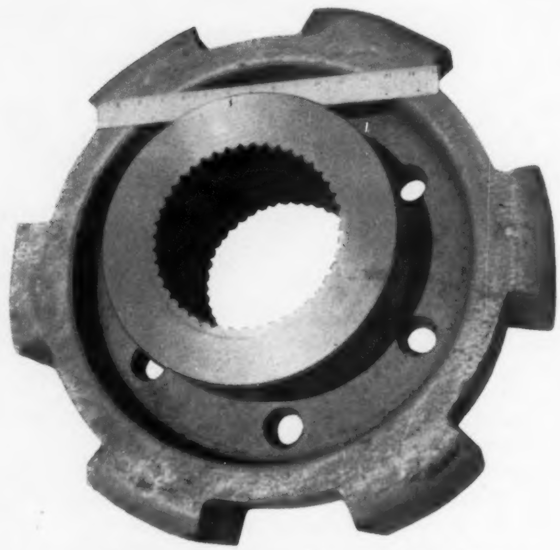


Figure 3
Jaw Clutch



A finished jaw clutch casting weighing 493 lbs. See Figure 3 above.

shown in Figure 1 have fillets on both the casting side and the riser side.

The second stage of the innerbore project applied to a combination drum and sprocket complicated by relatively thin sections and hubs that must be free of shrinkage (Figure 2).

There are two contacts in each hub with all measuring 1 inch x 1/2 inch. Core box is split longitudinally. The real secret of success, however, lies in properly placing the reinforcing rods in the core. The core rods running through the sand between the contacts must be bent at both ends. This prevents the core from breaking in a horizontal plane through the contacts when subjected to ferrostatic pressure.

In cleaning the casting the entire riser assembly is pressed out of the bore. These contacts cannot be cut out because of the small size of the bore. Fortunately they break off clean and do not require any finishing.

The result of applying an innerbore riser to this job has been a clean casting with a minimum of time required in the cleaning room.

After meeting with such success on the drum casting we chose to tackle the jaw clutch shown in Figure 3 as the third application.

The first sample casting was made using 1-1/2-inch square openings with four contacts in the drag and four in the cope. This resulted in small shrinks under each contact. Without changing the 5/8-inch thickness of the core, the contacts were enlarged to 2 inches x 2 inches and a sound sample casting was produced.

The real concern in feeding this casting was whether or not we could feed the jaws through the web which is 2 inches thick. Inspection revealed that the jaws were perfectly sound with no internal shrinkage.

Up to this point all of the innerbore applications were plain carbon steel. The next application, shown in Figure 4, is a bevel gear cast from an alloy steel of approximately the A.I.S.I. 8740 composition. The steel analyzed:

Carbon	0.38-0.42%
Manganese	0.90-1.10%
Chromium	0.60-0.80%
Nickel	0.40-0.60%
Molybdenum	0.20-0.30%

Our experience has been that this alloy is very sluggish and difficult to feed adequately.

The bevel gear weighs 520 pounds. The principal difficulty lay in feeding through the web which has six 1-1/2-inch holes. This is similar to the jaw clutch except that the bevel gear is larger and complicated by being an alloy difficult to cast.

Our first attempt at feeding was through four 1-1/2 inch x 1-1/2 inch contacts. This resulted in a shrink

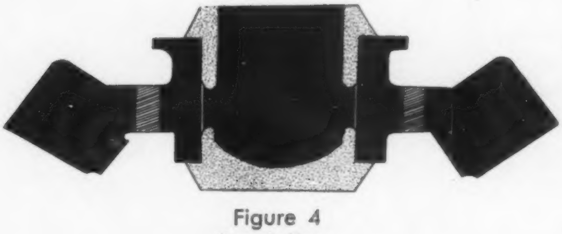


Figure 4
Bevel Gear

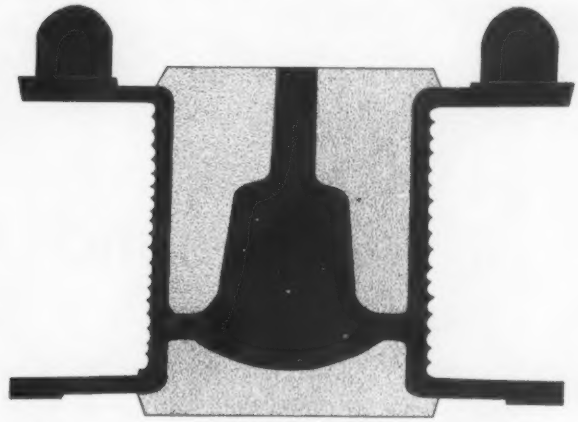


Figure 5
Drum Lagging

A finished bevel gear weighing 520 lbs. was cast from alloy steel. See Figure 4 above.

extending from the contact into the bore. The contacts were increased to 2-1/2 inches x 2-1/2 inches with a 5-inch header. The core thickness remained the same at 5/8 inches. Inspection revealed that the casting was entirely sound and free of any internal shrinkage.

Drum lagging of the general type shown in Figure 5 is a major tonnage item and has been a continuous rigging problem. This casting weighs 535 pounds but we have other drum laggings weighing from 150 to 1800 pounds.

In Figure 5 it should be noted that the point where the barrel joins the flange is especially difficult to feed. Previously this casting was rigged with two 6-inch blind headers on the lower flange. The gate came down the center under the mold cavity and into the headers. Headers are also on the top flange.

The innerbore riser that replaced the multiple headers is connected to the casting by two 1-inch x 4-inch contacts. The first sample casting was sound and free of sand defects. The job was analyzed for the purpose of reducing the size of the contact but it was concluded that there would be little to gain.

The use of innerbore risers on drum lagging castings has resulted in reduced cleaning time, increased yield, and generally higher quality casting.

The innerbore core boxes have been rigged for blowing. Since a core of this type is subjected to maximum errosive conditions, they are all dipped in a zirconite wash and oven dried.

Several sand mixtures have been evaluated. The most satisfactory is:

New Sand (AFS Fineness No. 63-65)	–	720 lbs.
Mogul	–	8 lbs.
Silica Flour	–	18 lbs.
Western Bentonite	–	2 lbs.
Ammonium Nitrate (Pelletized)	–	1 lb.
Oil	–	6 quarts

The baking cycle is 2 hours and 20 minutes in a tower oven controlled at 425 F. When washed, the baked cores are inspected carefully for soft spots and cracks.

The first casting produced with each new innerbore is destroyed for inspection purposes. The sample casting is visually inspected prior to blasting. After blasting with the headers attached, it is again visually inspected to detect any signs of core erosion. Headers are then removed and casting is processed through the cleaning room including the normal heat treatment. Final inspection includes magnetic particle and gamma ray, followed by sectioning with a power saw.

If the initial sample casting shows shrinkage or any other defect requiring a change, the change is made and another sample is cast. The same inspection is repeated for each sample.

During the early stages of innerbore development an additional sample was inspected from each run after the job was put into production.

The application of innerbore risers has certainly proven successful in the foundry division of the American Hoist & Derrick Co. This is not meant to infer that this technique is a "cure all." It is a useful tool but requires close inspection of cores and close attention to detail. A bad batch of cores can result in real trouble. When an innerbore core breaks down undesirable sand inclusions are scattered throughout the casting. However, with adequate precautions, the concept offers many advantages.

New Sand Mix Doubles Core Production

At the Massena Foundry of General Motors, new technology enables the same number of cores to be produced as formerly but in one-half the time.
Complete collapsibility is achieved at low temperature (1360 F).
Aluminum cylinder heads are de-cored in 10 seconds.
Mix, with a bench life of some 24 hours, costs less than mix previously used.
Core box wear has been reduced to a minimum, with core boxes lasting more than a year.

Dramatic savings have been effected at the Chevrolet Foundry, Massena, N. Y. with a new sand mix that collapses readily, and has easy clean-out characteristics.

Adapted for use with the firm's shell core blowing machines, the mix (having a urea formaldehyde resin as the binder) enables General Motors' engineers to produce as many cores in one and 1/2 shifts as they produced previously in three shifts using phenol formaldehyde-type shell cores. One shift production now equals over 1920 intake manifold cores. Besides doubling the productivity per core blowing machine, the urea formaldehyde-base mix costs less than previous shell mix and casting cleaning has been drastically simplified.

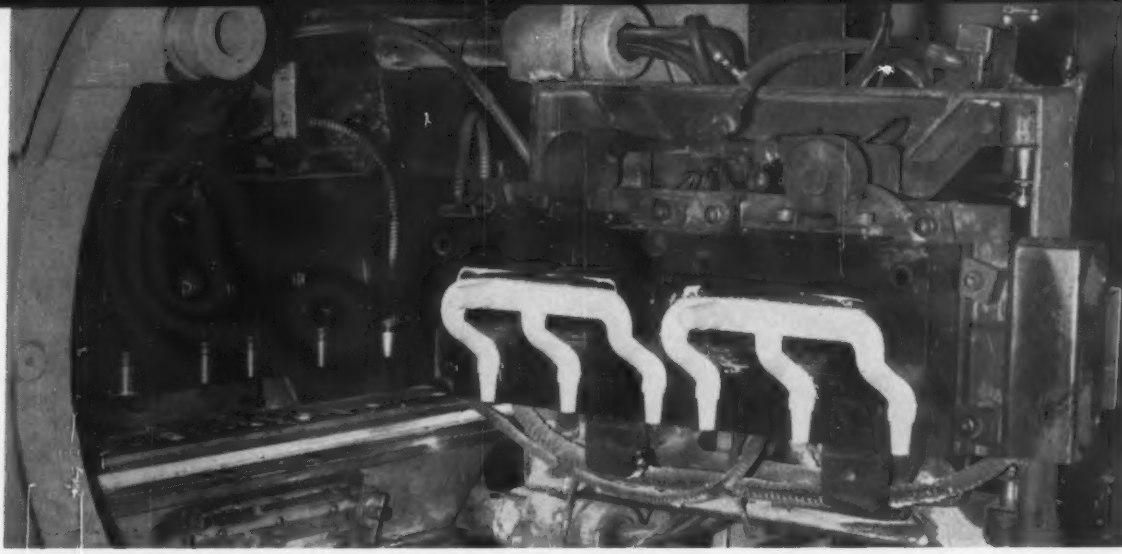
To use a rollover-type shell core blower for new process several modifications were made. A 400 pound batch of sand (round grained 75 gfn silica) is mixed with the binders (an acid catalyst) in seven minutes and transported to blower in a four wheeled steel hopper. About 50 pounds is shovelled into storage hopper on the machine. Mix has a bench life of at least 24 hours, perhaps even longer. The core boxes used in shell process usually need to have some vents added. The mix is wet and sluggish so blow plate holes require enlarging. Box is electrically heated to around 400 F. Because of its low stickiness, silicone parting agent need only be applied several times a day.

Two 1.842 pound manifold cores are simultaneously blown and cured in the dual cavity box in about 32 seconds. Actually the core temperature only needs to reach about 300 F to trigger the chemical reaction between the binder and the acid. The polymerizing action is sufficiently exothermic to complete the core hardening after it is removed from the core box. Just enough time is spent in the box to give core a hard shell with enough strength to stand stripping and handling.

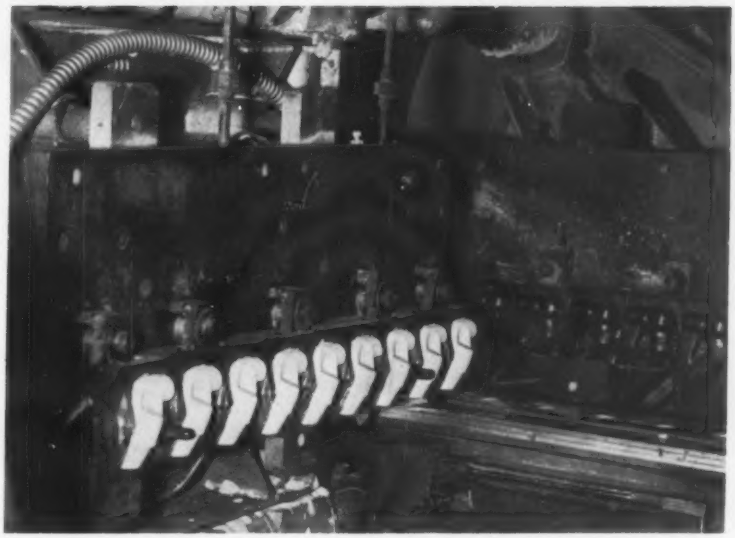
The entire blowing, curing, and stripping cycle occupies about 60 seconds for the two manifold cores. The exhaust port cores are blown nine at a time in a similar length cycle.

The undesirable odor normally associated with urea resin heating is completely absent. Hoods over the machine and a perforated work table with a down draft keeps all fumes out of the foundry environment.

Core box wear has been no problem at the Massena foundry. The same gray iron boxes have been used for blowing shell and furfural cores for over a year. Some have produced over 350,000 cores and are still in service. Except for occasional replacement of vents no repairs have been necessary. The cores are used without a wash. Being non-hygroscopic they



1. Hot core box swings open as soon as manifold core is partially cured. New sand mix enables one shift to produce more than 120 intake manifold cores.



2. It takes a 60 second cycle to blow, cure and strip nine exhaust ports cores. A rollover-type shell core blower was modified to handle the new mix. The mix has a bench life of at least 24 hours.

3. Cores are sufficiently strong after 60 seconds to be handled manually without damage. Because mix is wet, the core blower blow plate holes had to be enlarged.

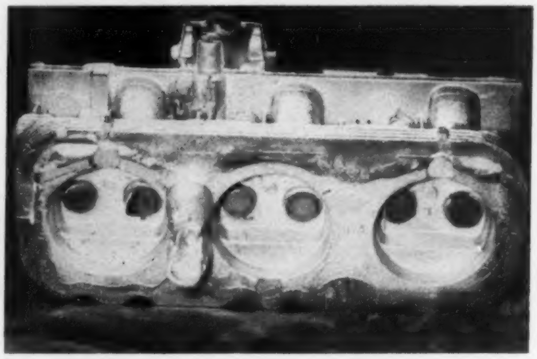
can be stored indefinitely without deterioration. Racks of cores are delivered to the casting area where they are set in a multi-piece permanent mold. One manifold and three exhaust port cores are used in making each cast aluminum head.

Permanent Mold Casting

The mold is positioned over an electric holding furnace (resistance or low frequency induction). Molten aluminum alloy 356 is forced up through a ceramic tube immersed in the melt by 6-9 psi air pressure exerted on top of the melt. Metal fills mold and feeds from the melt until casting solidifies—about a 5-minute period. When air pressure is released the molten metal runs back into the melt leaving just a short sprue stub attached to the casting. With no riser metal to remelt, yield is very high—above 96 per cent! Occasionally core gas can be a problem. A vent located at the end of the carburetor print on the manifold core is attached to a vacuum system. By drawing a slight negative pressure at the end of the core, harmful gases can be removed.

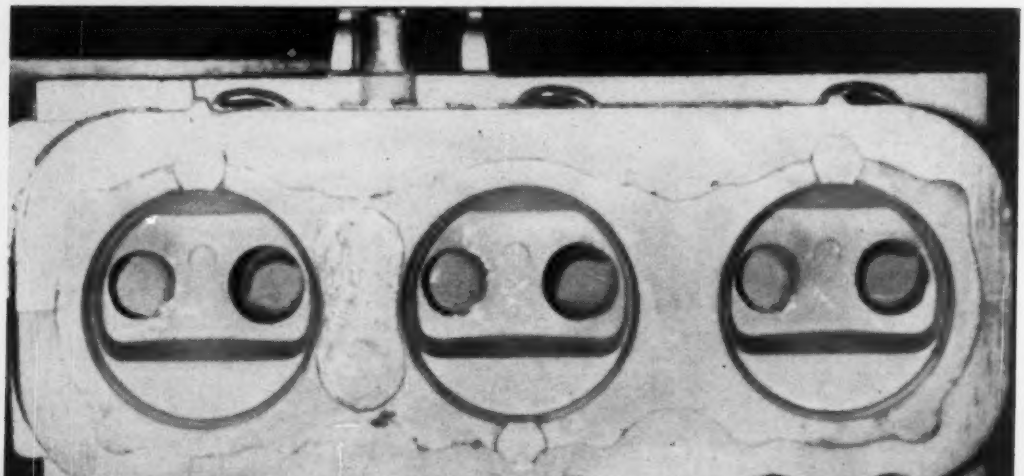
By formulating their own mix, General Motors has succeeded in achieving complete collapsibility at the relatively low temperatures of aluminum casting (1360 F.). Considerable time, effort, and walnut shells were consumed in cleaning other type cores from the intricate manifold and exhaust passageways. Now the aluminum cylinder heads are de-cored in 10 seconds by a straight 100 psi air blast in a rotary table blast machine. And *no* abrasive is required.

After core removal and some hand cleaning the cast aluminum heads are artificially aged at 400 F and shipped to the GMC engine plant in Tonawanda, N. Y. All the aluminum castings for the Chevrolet Corvair engine are made at Massena plant either by semi-permanent mold or die casting. The plant is supplied with hot metal directly from a Reynolds Metals Co. reduction plant which is located about one mile away.



4. One manifold and three exhaust port cores are used in multi-piece permanent mold to make this cast aluminum head. Mold is positioned over an electric holding furnace. Molten aluminum alloy 356 is forced through ceramic tube immersed in the melt. Metal fills mold and feeds from the melt until casting solidifies, about five minutes. There's no riser metal to remelt, consequently yield is above 96 per cent.

5. Easy collapsibility of cores permits their removal in 10 seconds with an air blast containing no abrasive material. The cast aluminum heads are then artificially aged at 400 F.



Circle No. 149, Pages 145-146

Circle No. 147, Pages 145-146

S. C. Massari

Castings Congress Papers

Market opportunities are revealed for metal patterns, investment casting of four magnesium alloys, low frequency melting of bronze alloys, and phosphorus refinement of hypereutectic aluminum silicon casting alloys. Other papers deal with the direct reduction of iron, the effect of wood flour in a clay-sand-water system and investigation into the CO_2 process.

TECHNICAL HIGHLIGHTS

Aluminum-Silicon Phosphorus Refinement 61
Commercial possibilities of hypereutectic aluminum-silicon casting alloys have been greatly increased through refining of the silicon constituent. Two types of phosphorus-containing inoculants produce a high degree of primary silicon refinement in a 16 per cent silicon permanent mold casting alloy. Remelting of ingots containing optimum phosphorus additions does not reduce the degree of refinement until the third or fourth remelting.

Investment Mold Feeding Distances 70
Three methods exist for increasing the feeding distance in carbon steel round bars using ceramic molds. These are higher mold temperatures, higher pouring temperatures, and higher carbon content for the same pouring temperature. The data is found to be linear for the relationship between length of sound bar and the diameter over the range between 1/4 in. and 1 in.

Effect of Wood Flour 73
Adding wood flour to clay-water-sand systems does not in reality lower dry compression strength of western bentonite bonded sands. The addition simply increases the water content required to obtain a given dry compression level. On the other hand, dry compression strengths of southern bentonite sands are drastically reduced by wood flour additions. While simple bentonite-sand-water systems experience drastic change from brittle to plastic with small change in water, the same combinations with wood flour added experience the change from brittle to plastic over a substantially wider range of water content. Simple fireclay bonded sands exhibit this property, and additions of wood flour did not influence this water range except to shift it to higher water levels.

Machined Patterns Can Be Competitive 89
Adoption of modern production methods and elimination of traditional time-consuming repetitive steps will place metal patterns on a competitive footing with newer patternmaking techniques. Improved pattern engineering and automatic duplicating machines are keys to patternshops regaining metal pattern business.

Direct Reduction of Iron 95
Hot metal cost competitive to cupola melting while using low rank materials has been achieved in pilot plant operations. The liquid iron can be pigged or used as hot metal. Already in use in Europe, the process shows considerable possibilities in this country. It is estimated that in commercial operations total production costs will range from $38 to about $59 per ton of iron depending on the plant capacity and grade and source of raw materials. These costs compare favorably with the estimated cost of $58.40 for hot metal in an average foundry.

Low Frequency Melting of Bronze Alloys 103
Closer metallurgical control, decreased production costs, and increased physical characteristics are available through low frequency induction melting of bronze alloys. Careful control of zinc content makes savings possible in production of 85-5-5-5 alloy.

Investment Casting of Mg Alloys 111
Four magnesium alloys can be cast satisfactorily in a variety of shapes by the investment casting process with tensile strengths exceeding the minimum requirements of government and aeronautical specifications. New fields appear open for aircraft and missile applications.

CO_2 Process Highlights 121
Investigation on 1-in. specimens discloses that the amount of binder required increases as the mesh size of the sand decreases; coarse sands do not form strong mixtures; and higher strengths are obtained with higher percentages of binder.

The technical articles appearing in this preview section of MODERN CASTINGS are the official 1961 Castings Congress Papers. Nearly 100 technical papers are scheduled for presentation at the 65th Castings Congress to be held May 8-12 in San Francisco. Readers planning to participate in oral discussion of these papers during the Castings Congress are advised to bring them to the technical sessions for ready reference. Written discussion of these papers is welcomed and will be included in the 1961 AFS TRANSACTIONS. Discussions should be submitted to the Technical Department, American Foundrymen's Society, Golf and Wolf Roads, Des Plaines, Ill.

HYPEREUTECTIC ALUMINUM-SILICON CASTING ALLOYS PHOSPHORUS REFINEMENT

by F. L. Arnold and J. S. Prestley

ABSTRACT

Optimum conditions and limitations of the phosphorus refinement process were investigated for a 16 per cent silicon casting alloy. Two types of phosphorus-containing inoculants were used, namely a commercially available nucleant containing 20 per cent red phosphorus, and a phosphor-copper alloy with 15 per cent phosphorus. Experimental melts of the alloy were cast into permanent mold and sand mold wedges giving a wide range of solidification rates. Metallographic specimens taken from an area of measured chill rate revealed the actual degree of refinement.

The optimum amount of phosphorus necessary for refinement was determined for both inoculants. Solidification rate was demonstrated to have a great influence on total primary silicon refinement, as well as some slight degree of modifying effect on the eutectic structure. Also investigated were the effects of remelting the refined alloy, temperature of the melt and holding time.

Metallographic examination of the refined silicon particles at high magnifications revealed tiny crystal shapes believed to be the phosphorus-containing nuclei. Observations supported the nucleation theory, commonly believed to be the mechanism of phosphorus refinement.

INTRODUCTION

It has been known for some time that the addition of small quantities of sodium to hypoeutectic aluminum-silicon casting alloys greatly modifies the eutectic structure of these alloys and likewise enhances their mechanical properties. While the alloys had been well known before the modifying technique was patented by A. Pacz in 1921, this date actually marks the beginning of their commercial importance.[1]

The hypereutectic alloys have had a somewhat similar history. The first German patent was obtained in 1924, at which time considerable interest was aroused by the low coefficient of thermal expansion and good wear resistance of the high silicon alloys. However, the metallurgical difficulty in this case was that the large primary crystals of silicon adversely affected certain properties of the alloys. Considerable research was directed toward the problem of refining the silicon constituent, and eventually it was found that phosphorus performed this needed function when introduced into the molten metal. Thus the door was opened to the potential commercial use of the hypereutectic alloy system.

REFINEMENT THEORY

The mechanism of the refinement of primary silicon by phosphorus appears to be different from any of those generally attributed to sodium in eutectic modification. One theory is that sodium in hypoeutectic alloys reduces the interfacial tension between the eutectic alpha aluminum and the eutectic silicon constituents, increasing their interfacial angle and allowing the aluminum to envelop and arrest the growth of the eutectic silicon platelet.[2]

The theory of phosphorus refinement is that insoluble aluminum phosphide (AlP) particles are formed in the melt after addition of phosphorus, and these act as nuclei for primary silicon crystals.[3,4,6] Both have a diamond cubic crystal habit and a similar lattice constant (Si, $a_o = 5.43$ Å: AlP, $a_o = 5.45$ Å). Like sodium modification, phosphorus refinement must be accomplished in the molten metal during the process of solidification, since there is no way to refine large silicon crystals once they have been formed in a casting. Thus the process is one in which the foundry is vitally concerned.

Although the necessity for silicon refinement has been established there remains many practical questions, such as the optimum form and amount of the inoculant necessary and the effect on refinement of solidification rate, high melt temperature and several remeltings. The question of solidification rate is of particular importance because the choice of casting method may be influenced in part by required solidification rates.

REFINEMENT NECESSITY

The hypereutectic aluminum-silicon alloys are presently being considered for applications, such as the automobile engine, in which they will be subjected to severe wear and elevated temperatures. In their contemplated use, the castings will often require considerable machining.

Figure 1 shows the effect of refinement on tensile strength of binary aluminum-silicon alloys containing 12 to 24 per cent silicon. The unrefined tensile strength drops sharply with increasing silicon to

F. L. ARNOLD and J. S. PRESTLEY are Research Engineers, Metallurgical Research Laboratories, Reynolds Metals Co., Richmond, Va.

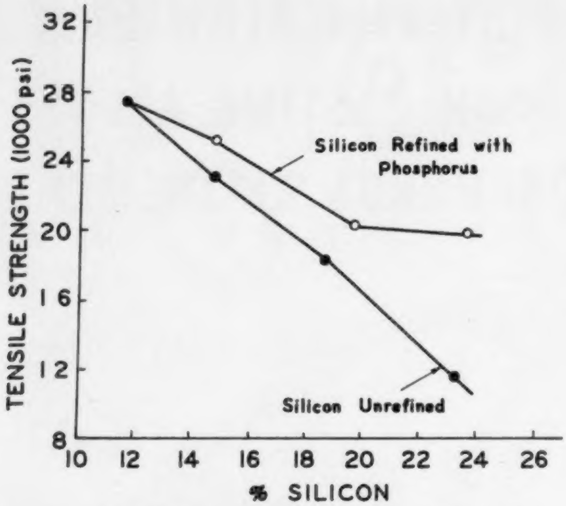


Fig. 1 — Refinement effect on tensile strength of binary alloys containing 12-24 per cent silicon. As-cast permanent mold test bars.

12,000 psi at 23 per cent silicon.[5] On the other hand, the tensile strength of phosphorus refined alloys drops to and levels off at 20,000 psi in the range of 18 to 23 per cent silicon.

The detrimental effect of unrefined primary silicon on machinability is relatively well known. The large crystals tend to break up under the machine tool, reducing tool life. Also, the hard silicon particles embedded in the soft aluminum matrix cause variations in resistance offered to the tool, setting up local heating and thermal expansion. This, in turn, leads to excessive local removal of metal during machining, causing variations in the dimensions of mass-produced precision parts.[6] Optimum wear resistance may require refined silicon particles for similar reasons.

EXPERIMENTAL TECHNIQUE

The particular casting alloy used for refinement studies contained nominally 16 per cent silicon. Laboratory work has shown that other elements like copper, magnesium, manganese, iron and titanium, commonly found in hypereutectic silicon casting alloys, have no effect on primary silicon so far as amenability to phosphorus refinement is concerned.

Both a phosphor-copper alloy containing 15 per cent phosphorus, and a commercially available finely divided nucleant mixture[7] containing approximately 20 per cent red phosphorus, 10 per cent potassium titanium fluoride and 70 per cent potassium chloride were used as inoculants. Phosphorus pentachloride has been used as a refiner, but since it is expensive, produces objectionable fumes and offers no advantage over the inoculants just described, it was not considered in these investigations.

Ten-pound melts were prepared in a silicon carbide crucible heated in a gas-fired furnace. When phosphor-copper was used as the inoculant, the addition was made as shot as soon as a heel of molten metal was formed in the crucible. The metal temperature was then raised to 1500 F (815 C) to get the shot into solution. Later experiments indicated that it was not necessary to go to this temperature if the shot was crushed before addition. The alloy was then brought to 1400 F (760 C), fluxed with chlorine for 5 min and held 5 to 10 min before casting at 1400 F (760 C).

For inoculations of the commercial nucleant mixture, the addition was made at 1400 F (760 C) by plunging the inoculant, wrapped in foil, into the melt with a carbon "phosphorizer" having sufficient holes to allow intimate contact of the refining agent with the metal. The alloy was then fluxed and cast as described previously for the phosphor-copper inoculant.

In order to evaluate the effect of solidification rate of the casting, known from preliminary work to have an influence on silicon particle size, wedge-shaped permanent and baked oil sand molds were designed. After treatment, metal from each experimental melt was poured into these molds. Solidification time was determined with calibrated iron-constantan thermocouples inserted into the castings near the tip, at the center and near the top of the wedge. Solidification rates (between the liquidus and solidus temperature) varied from 61 F (16 C) to 1650 F (890 C)/min (Fig. 2). These three areas of known solidification rate were chosen for metallographic examination.

RESULTS AND DISCUSSION

Optimum Phosphorus Addition — Phosphor-Copper

One of the important conclusions to be derived from this work was the amount of the 15 per cent phosphor-copper alloy and the commercial inoculant necessary to effect optimum refinement. Optimum refinement, in this case, is defined as the finest primary crystal size obtainable within the range of inoculant additions studied.

In the permanent mold castings refined with phosphor-copper the addition of only 0.01 per cent phosphorus to the casting alloy yielded silicon particles only slightly refined, as compared with an alloy containing no phosphorus at all. However, a total addition of 0.05 per cent phosphorus produced optimum refinement, and further additions up to 0.17 per cent phosphorus provided no further reduction in particle size. Samples with phosphorus additions of between 0.01 and 0.05 per cent were then prepared, and it was found that 0.02 per cent was the minimum addition for which optimum refinement could be expected. Figure 3 shows the coarse silicon particles in an alloy containing no phosphorus, and the effect on silicon particle size of increasing additions of phosphorus.

In the more slowly solidified sand castings refined with phosphor-copper the same refinement trend was found with increasing phosphorus additions, except that the amount needed for optimum refinement was shifted from 0.02 to 0.05 per cent for the permanent mold castings to from 0.05 to 0.08 per cent for the sand castings.

The addition of phosphorus by phosphor-copper alloy was found to be quite simple and reliable, as compared with other types of inoculants. Since the addition can be made when the metal begins to melt, a separate and time-consuming step is avoided

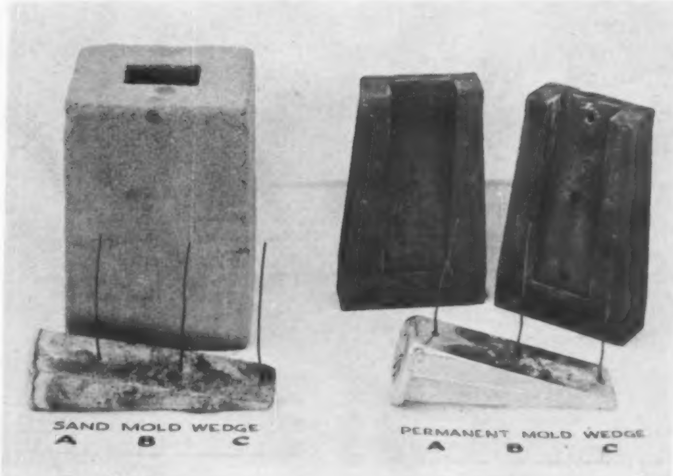


Fig. 2 — *Left* — Baked sand wedge mold and casting showing thermocouple locations. *Right* — Iron permanent mold and casting. The table lists solidification rates for respective thermocouple locations.

Mold Type	Position	Solidification, F (C)/min	
Sand	A	61	(16)
Sand	B	89	(32)
Sand	C	114	(46)
Permanent	A	286	(141)
Permanent	B	474	(246)
Permanent	C	1650	(899)

at a later point. Although the use of phosphor-copper does add copper to the casting alloy, it may be held to a minimum of only 0.06 per cent for each 0.01 per cent phosphorus added. This may be tolerable in an alloy which has a relatively high copper content to begin with, and it is possible that a part of the nominal copper content of the alloy could be added in this way.

Optimum Phosphorus Addition — Commercial Inoculant Mixture

Additions of from 0.20 to 1.25 per cent of a commercial refining inoculant containing 20 per cent red phosphorus revealed that an addition of 0.40 per cent was necessary for optimum refinement of both permanent mold and sand casting. The same refining trend was observed with this inoculant as with phosphor-copper, namely, that little refinement was obtained until a certain percentage of inoculant, (in this case 0.40 per cent) was added. With this amount, a fine silicon particle size was obtained which varied only slightly with additional amounts of phosphorus.

Figure 4 shows the effects of additions of increasing amounts of the commercial phosphorus-containing inoculant. This material has the advantage over phosphor-copper of not adding copper to the alloy, but it must be added to the melt in a separate operation after the metal is molten. Phosphor-copper may be added to the crucible at the beginning of the melting process.

Solidification Rate Effect

The rate at which the 16 per cent silicon alloy solidified was found to have a marked effect on primary silicon particle size in alloys both with and without phosphorus additions. With no phosphorus, however, even at the extremely rapid solidification rate [1650 F (899 C)/sec] at the tip of the permanent mold wedge casting, refinement was considerably less than satisfactory. This indicates that some means of artificial nucleation is essential for refinement of commercial castings. Figure 5 compares the microstructures of sand [solidified at 89 F (32 C)/min] and permanent mold [solidified at 1650 F (899 C)/min] wedge sections cast without phosphorus additions.

In general, a rapid solidification rate, such as was obtained in the permanent mold castings, coupled with at least the minimum addition of phosphorus, as discussed previously, produced the best refinement. Figure 6 compares the refinement of sand cast [solidified at 89 F (32 C)/min] wedge section with that of a permanent mold wedge section solidified at 1650 F (899 C)/min, both having additions of 1.0 per cent of the commercial refining inoculant.

Remelting Effect

The effect of remelting previously inoculated and cast metal was considered in these investigations because of the practical situation where scrap metal may be melted several times in a foundry. One remelt appeared to have no effect on the refined structure, while two to four remelts had a slight coarsening effect on the silicon particles. This was most noticeable in the more rapidly chilled section of the permanent mold wedge where refinement was excellent to begin with. Figure 7 illustrates these observations (remelted metal was fluxed with chlorine before casting).

Holding Time and Melt Temperature Effect

Since in the foundry operation it is impossible to insure that inoculated molten metal will always be immediately poured into molds, the question of the effect of holding time (after inoculation) on refinement becomes important. Laboratory work with the wedge castings indicated that properly inoculated metal could be held for at least 1½-hr at pouring temperature with no great change in silicon refinement, although there existed a tendency towards slightly coarser particles.

When melts were inoculated at 1400 F (760 C) with the commercial nucleant powder, the subsequent heating to still higher temperatures revealed a trend toward slight coarsening in the range of 1500 F (815 C) to 1700 F (927 C). Thus, metal temperature is not critical for this inoculant at temperatures normally used in melting practice for this alloy. In these studies, the melt was cooled again to the

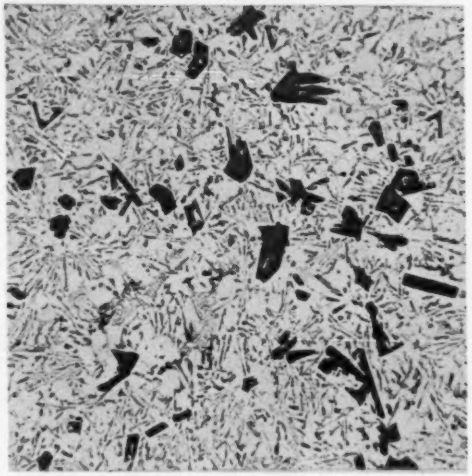


Fig. 3a — No phosphorus addition. Silicon particle coarse.

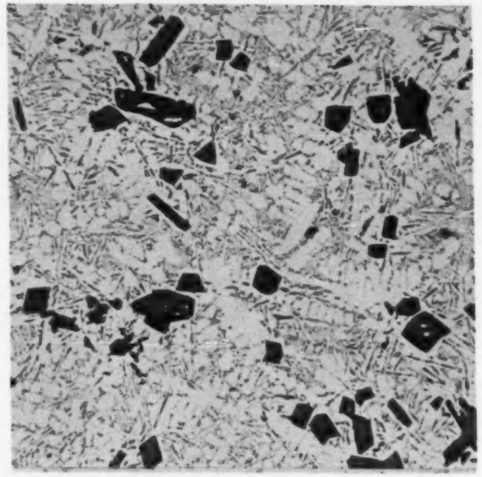


Fig. 3b — Addition of 0.01 per cent phosphorus. Silicon refined only slightly.

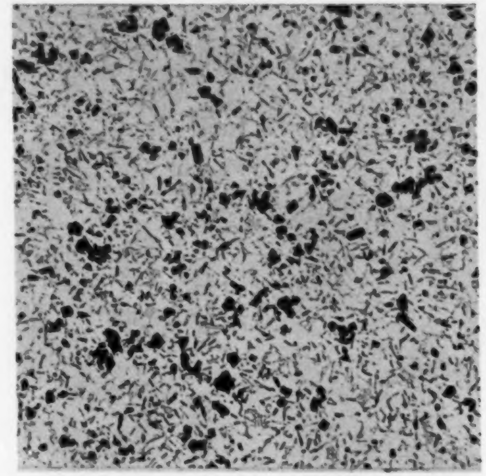


Fig. 3c — Addition of 0.02 per cent phosphorus. Optimum refinement.

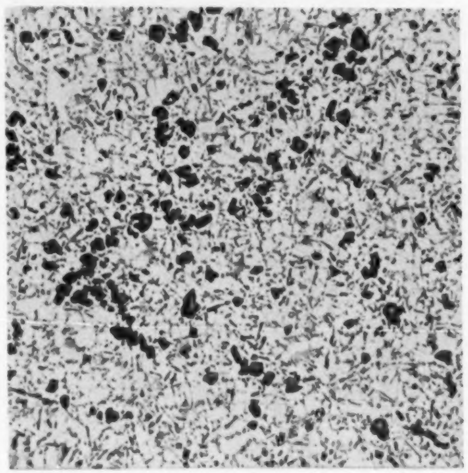


Fig. 3d — Addition of 0.05 per cent phosphorus. Optimum refinement.

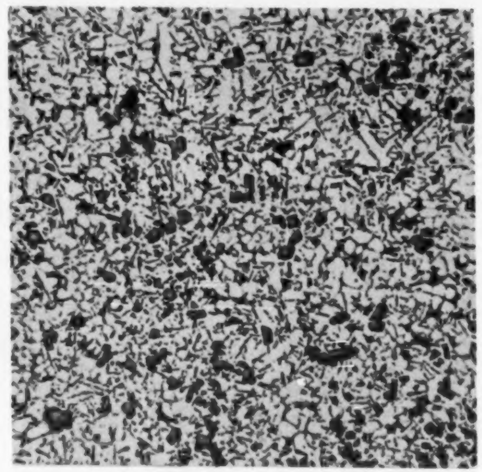


Fig. 3e — Addition of 0.08 per cent phosphorus. Optimum refinement.

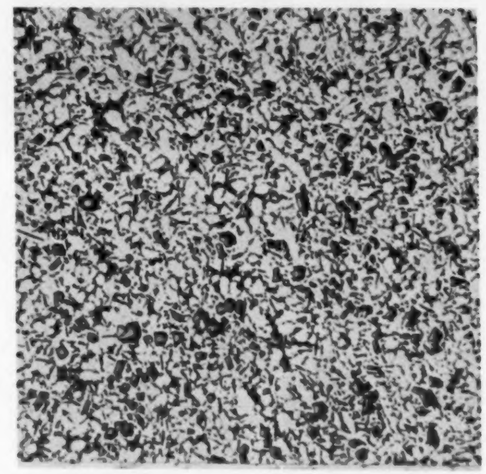


Fig. 3f — Addition of 0.17 per cent phosphorus. Optimum refinement.

Fig. 3 — P-Cu additions effect on primary silicon refinement. All samples taken from *B* section of permanent mold wedge, solidified at 474 F (246 C)/min. Unetched. 100 ×.

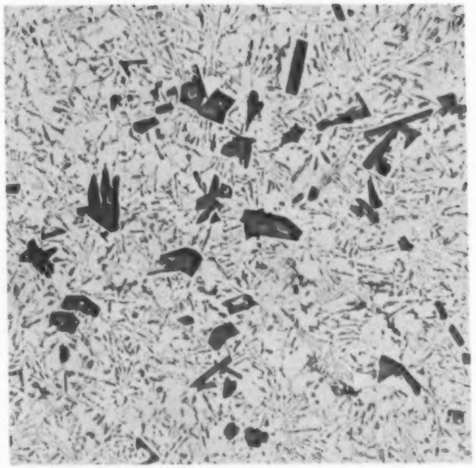


Fig. 4a — No phosphorus addition. Silicon particle coarse.

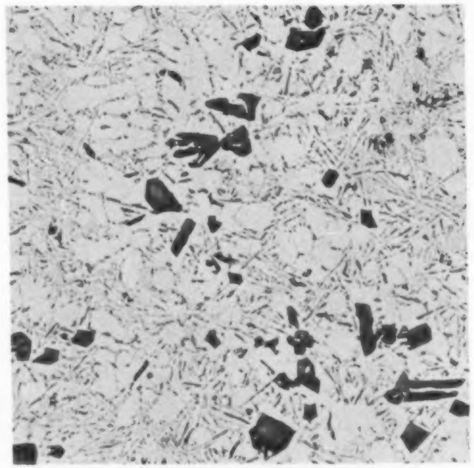


Fig. 4b — 0.20 per cent nucleant mixture. Silicon refined only slightly.

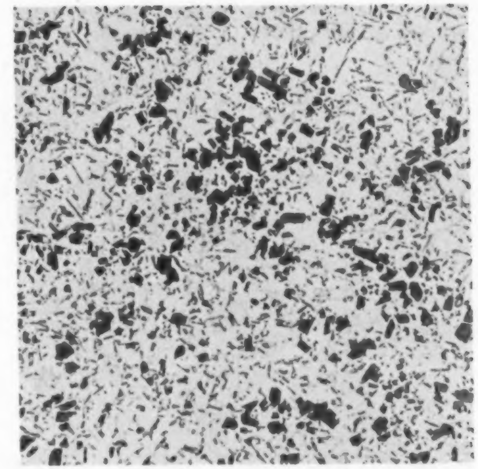


Fig. 4c — 0.40 per cent nucleant mixture. Silicon particles well refined.

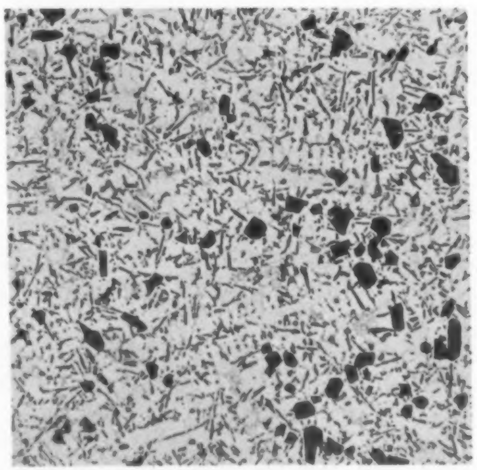


Fig. 4d — 0.60 per cent nucleant mixture. Silicon particles well refined.

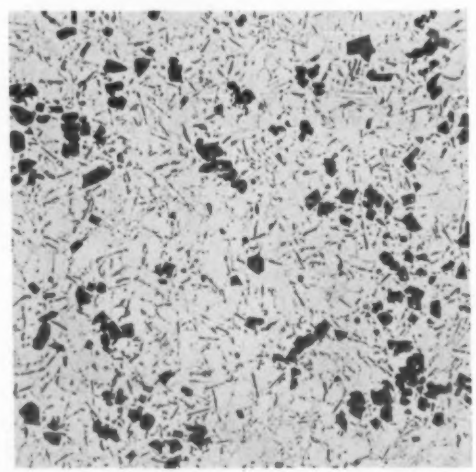


Fig. 4e — 0.80 per cent nuclean mixture. Silicon particles well refined.

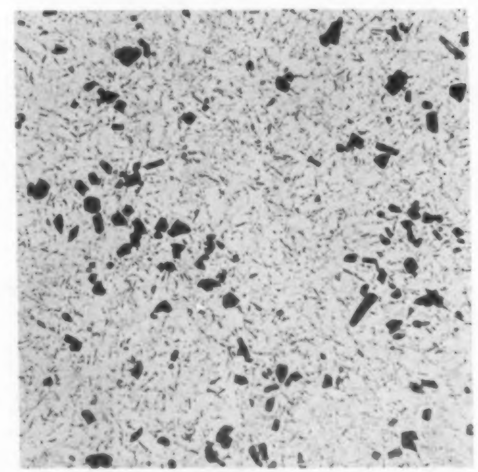


Fig. 4f — 1.0 per cent nucleant mixture. Silicon particles well refined.

Fig. 4 — Commercial nucleant mixture effect on primary silicon refinement. All samples taken from *B* section of permanent mold wedge, solidified at 474 F (246 C)/min. Unetched. 100 ×.

Fig. 5 — Solidification rate effect on alloy with no phosphorus addition. Unetched. 100 ×.

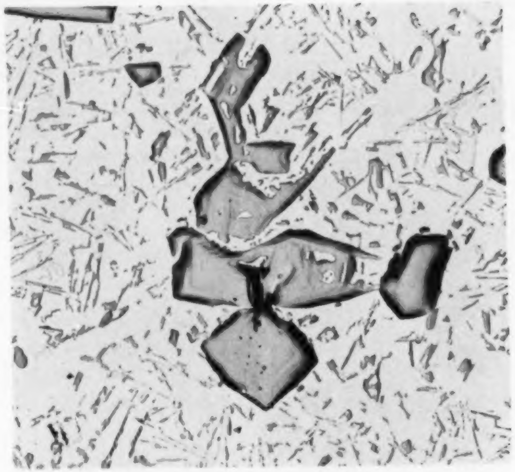


Fig. 5a — Solidification rate 89 F/mn in sand mold *B* section. Coarse silicon particles.

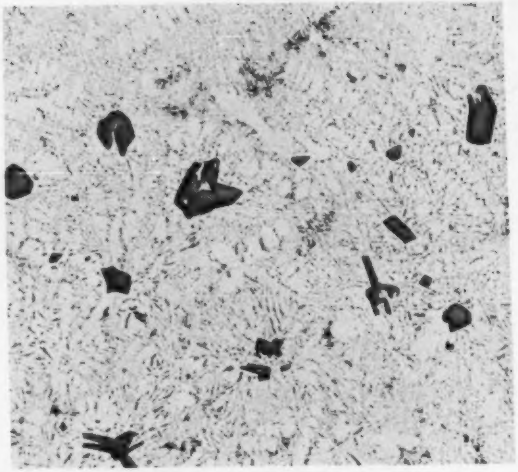


Fig. 5b — Solidification rate 1650 F (899 C)/min in permanent mold *C* section. Silicon finer, but still not well refined.

Fig. 6 — Solidification rate effect on alloy with addition of 1.0 per cent commercial nucleant mixture containing phosphorus. Unetched. 100 ×.

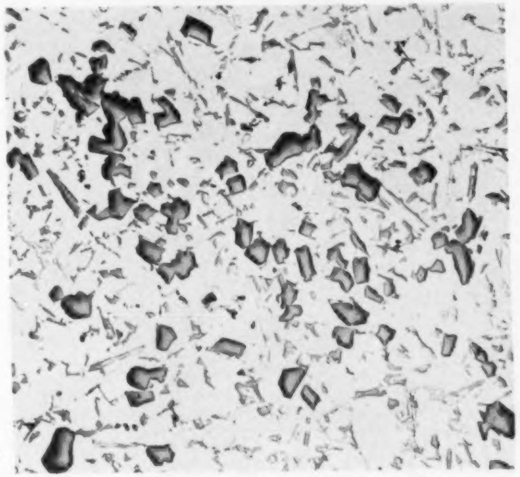


Fig. 6a — Solidification rate 89F (32 C)/min in sand mold *B* section. Silicon particles fairly well refined.

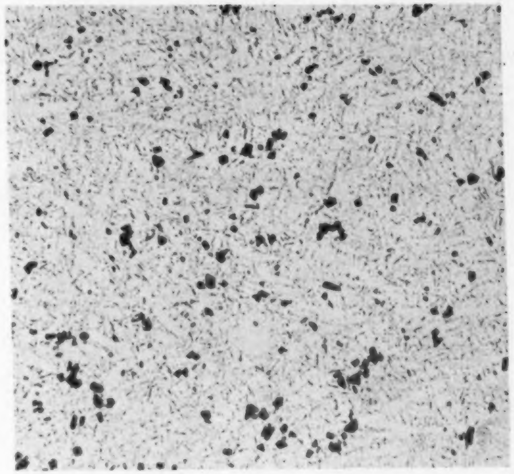


Fig. 6b — Solidification rate 1650 F (899 C)/min in permanent mold *C* section. Excellent refinement.

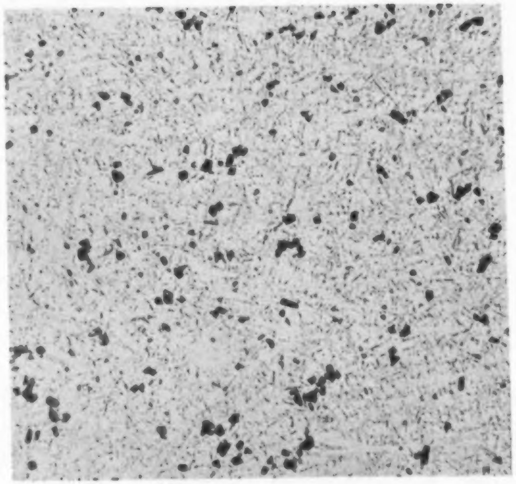


Fig. 7a — Original melt. Good refinement.

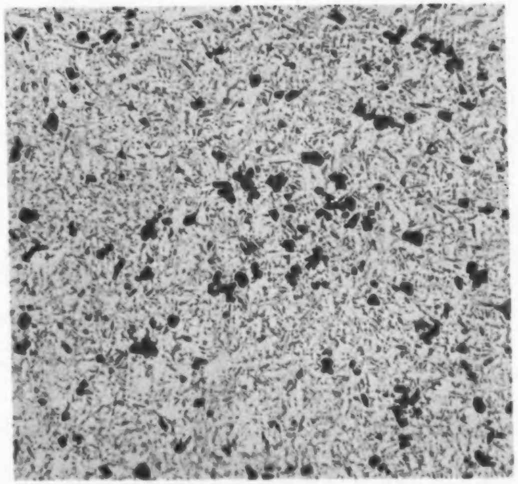


Fig. 7b — After four remelts silicon particles slightly coarser than original melt.

Fig. 7 — Four remelts effect on alloy refined with 1.0 per cent commercial nucleant mixture. Samples taken from C section of permanent mold wedge solidified at 1650 F (899 C)/min. Unetched. 100 ×.

Fig. 8 — Commercial nucleant mixture addition effect on eutectic structure. Samples taken from C section of sand mold wedge solidified at 61 F (16 C)/min. Unetched. 100 ×.

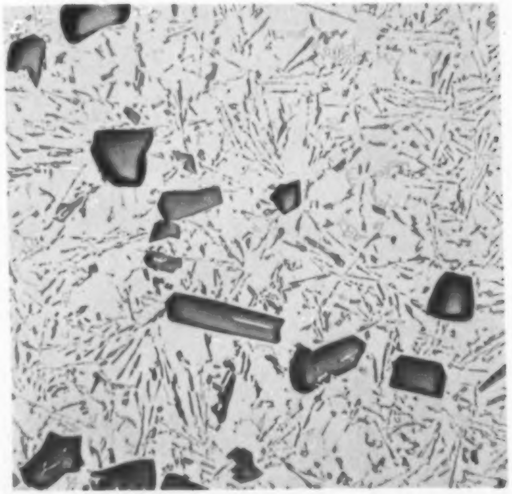


Fig. 8a — No phosphorus addition. Coarse, acicular eutectic structure.

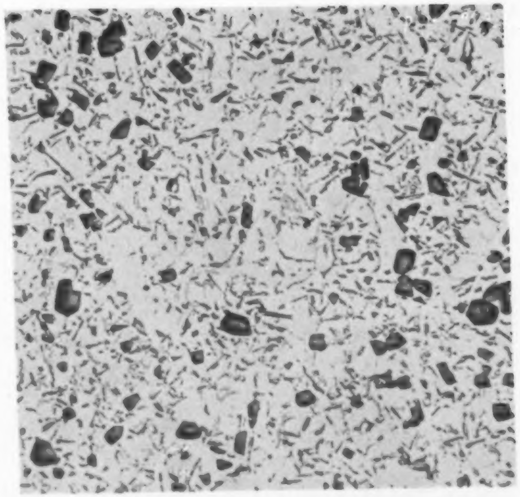


Fig. 8b — 1.25 per cent commercial nucleant addition. Eutectic structure somewhat modified.

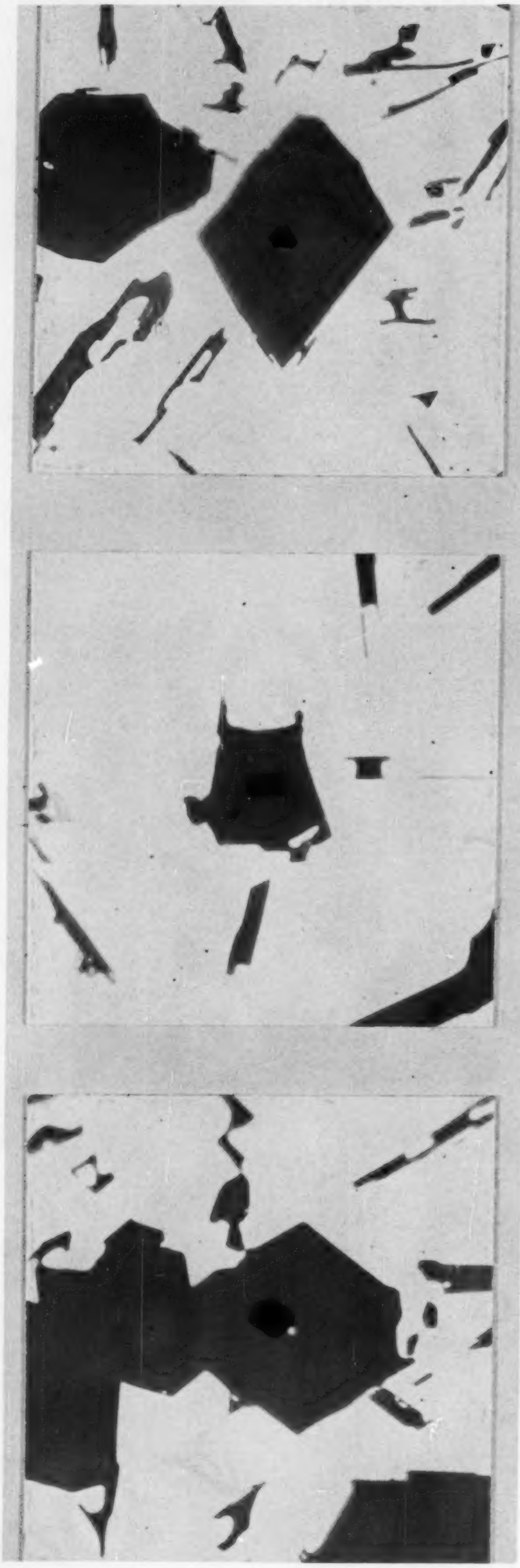


Fig. 9 — Primary crystals of silicon with nuclei of similar configuration. Unetched. 1500 ×.

normal casting temperature of 1400 F (760 C) for pouring.

Eutectic Structure

The fineness (or degree of modification) of the silicon eutectic structure in all of the phosphorus-refined samples studied was heavily dependent on solidification rate, as normally expected, but also appeared roughly proportional to the amount of phosphorus addition by either inoculant. In no case, however, was a structure obtained which approached that of sodium-modified metal. Figure 8 illustrates the effect of the commercial type inoculant on the eutectic structure of sand castings.

REFINEMENT MECHANISM

The mechanism of refinement by phosphorus, as mentioned previously, has been reported as a nucleation phenomenon. It is theorized that the formation of a crystal of the compound aluminum phosphide (AlP), having the same crystal structure as silicon and a similar lattice parameter, facilitates the nucleation of a primary silicon crystal onto its surfaces. Little data about the nature of occurrence of these nuclei crystals appear in the literature. Confirmation of their presence is necessary as the first step toward understanding the mechanism of refinement. The size of these "seed" crystals is of particular interest here in correlating the amount of phosphorus added to the amount of phosphorus retained in the primary crystals.

In order to determine whether nuclei crystals of detectable sizes were present, the polished samples of the phosphorus refined alloy were examined at about 2000 magnifications. Crystal shapes with configurations almost identical to the host silicon particles were observed in the approximate centers of a small proportion of the primary silicon crystals (Fig. 9).

Since there was a possibility that the shapes observed were actually some other phenomenon rather than crystals of aluminum phosphide (AlP), a sample of the alloy was cast without phosphorus addition. The solidification rate was rapid enough to yield primary crystals of a size approaching that of the phosphorus refined alloy. The rapidly chilled sample did not contain the crystal shapes observed in the phosphorus refined samples. It was, therefore, concluded that nucleating crystals were associated with phosphorus refinement.

Preliminary electron microprobe x-ray analysis confirmed the presence of phosphorus at the seed crystal site. This phosphorus presumably exists as the compound aluminum phosphide (AlP). However, more precise analysis is necessary to provide conclusive evidence as to the exact composition of the nucleating crystals.

Added vs. Retained Phosphorus

To obtain more information about the nuclei crystals observed, the *B* group of permanent mold samples refined with commercial nucleant powder were selected for closer study. Thirty measurements

on each sample gave an average nucleus diameter of from about 1.0 to 2.0 microns. The corresponding ratio of average nucleus diameter to silicon crystal diameter ranged from about 0.1 to 0.2. Samples refined with phosphor-copper, although given only cursory examination, were of about the same order of magnitude. Measurements were taken directly from the polished surfaces, with no correction for the probability that most of the nuclei would not be polished through the maximum dimension.

From these data, a first approximation of the amount of phosphorus contained in the nucleus (as a percentage of the alloy) was made assuming:

1) all of the primary silicon particles to contain a nucleus crystal.
2) the stoichiometric relationship of aluminum phosphide (AlP).
3) 4 per cent primary silicon.
4) the shape of both crystals to be cubes.

Phosphorus contents of about 0.001-0.010 per cent were indicated from the calculations. This amount was considerably less than the 0.04-0.25 per cent phosphorus added to the samples. Since chemical analysis gave 0.001 per cent or less, the obvious conclusion is that a considerable portion of the phosphorus is lost between the addition and casting operations.

Further, according to the calculated percentages, the amount of phosphorus retained did not continually increase with increasing additions. The variation was similar to that observed in this group of samples when comparing the degree of refinement to the percentage of inoculant addition. Both of these variations may be due to the possibilities for unpredictable losses inherent in adding the fine powder to molten metal.

Accuracy of Calculated Phosphorus

Within an order of magnitude, the agreement between calculated and analyzed phosphorus is fairly good, considering the assumptions necessary for calculation and the fact that the chemical analytical techniques were designed to include phosphorus in the matrix as well as in the primary silicon. An accurate analytical method, which will determine the amount of phosphorus in the primary silicon along with other improvements in measuring techniques, would provide a better understanding of the physical mechanism of nucleation. The present data, however, support the nucleation theory of phosphorus refinement. They also indicate that, because of losses during alloying, sufficient excess of phosphorus must be added to insure the retention of the amount necessary for nucleation.

CONCLUSIONS

The minimum percentage phosphorus addition required for a high degree of refinement appears to lie within a narrow range for both the commercial powder and phosphor-copper inoculants. Below this range of addition, little or no refinement is realized. Above this range, little increase in refinement is affected up to the maximum additions studied.

A high degree of primary silicon refinement can be obtained in a 16 per cent silicon permanent mold cast alloy using a minimum of:

a) 0.40 per cent commercial phosphorus-containing nucleant studied.
b) 0.02 per cent phosphorus added as 15 per cent phosphorus-copper alloy.

Somewhat more phosphorus is required to produce good refinement in the slower cooled sand cast wedges than in permanent mold castings when added as phosphor-copper alloy. Using the phosphor-copper inoculant, this amounted to 0.05 to 0.08 per cent phosporus instead of 0.02 per cent. Silicon particle size, even with optimum additions, is much coarser in sand than in permanent mold castings.

The metallic 15 per cent phosphorus-copper is easier to add to the melt than the commercial nucleant mixture, but it does add copper to the alloy. This amounts to 0.06 per cent copper for each 0.01 per cent phosphorus added.

The remelting of ingots containing optimum phosphorus additions does not have any noticeable effect on the degree of refinement until the third and fourth remelting. Even then, the coarsening is only slight.

For alloys inoculated with the phosphorus-containing commercial nucleant, maximum melt temperatures above 1500 F (815 C) produce some tendency towards coarsening of primary silicon particles.

Eutectic silicon fineness is dependent on the rate of solidification although phosphorus additions do have a slight modifying effect. However, both of these factors are not sufficient to even approach the degree of modification obtainable with sodium.

The presence of crystals in the centers of refined primary silicon crystals indicates that refinement is a nucleation phenomenon, as theorized.

ACKNOWLEDGMENT

The valuable contributions of the following personnel of Met. Rsch. Laboratories, Reynolds Metals Co., are gratefully acknowledged – G. E. Stein, R. S. Mapes, G. P. Koch and J. L. Jorstad.

REFERENCES

1. A. Pacz: U. S. Patent No. 1387900, Applied for Feb. 13, 1920; issued Aug. 16, 1921.
2. B. M. Thall and B. Chalmers, "Modification in Aluminum-Silicon Alloys," *Journal of the Institute of Metals, vol. 77*, p. 79 (1950).
3. E. M. Onitsch-Modl, "Recent Developments in the Metallurgy of Aluminum Piston Alloys with Hypereutectic Silicon Content," *Proceedings of the First World Metallurgical Congress*, p. 325 (1951).
4. Claude Mascré, "Modification of High-Silicon Aluminum Alloys and the Corresponding Structures," *Foundry Trade Journal*, p. 725 (June 25, 1953).
5. W. F. Smith, Metallurgical Research Laboratory Report (Unpublished).
6. W. Thury and H. Kessler, "An Effective Method of Grain Refining for Hypereutectic Aluminum-Silicon Alloys," *Light Metals, vol. 19*, p. 225 (July 1956).
7. British Patent, 792,172.
8. H. Kessler and H. L. Winterstein, "Significance of Particle Size of a Grain Refining Agent," *Light Metals, vol. 19*, p. 294 (Sept. 1956).
9. O. Tichy and R. Kissling, "A Hypereutectic Aluminum-Silicon Alloy," AFS TRANSACTIONS, *vol. 67*, p. 347 (1959).
10. R. A. Meussner, "The Structure of Aluminum-Silicon Alloys," *Naval Research Laboratory Report 5341* (July 31, 1959).

FEEDING DISTANCE OF BARS IN INVESTMENT MOLDS

by H. Present and H. Rosenthal

ABSTRACT

A study has been made of feeding range in investment molds. Armco iron, A.I.S.I. 1020 and A.I.S.I. 1095 steel were used to determine the effect of mold temperature and pouring temperature. Only the case of a round bar fed by an infinite riser was considered. The data were found to be linear for the relationship between length of sound bar and bar diameter over the range between ¼-in. and one in. Feeding range increased with mold temperature, pouring temperature and carbon content of the steel.

INTRODUCTION

Feeding distance of risers for steel bars and plates has been extensively investigated for sand molds. These data are of fundamental interest to those concerned with the gating of castings. Some of the newer ceramic mold casting processes, however, employ conditions which are not compatible with the data developed for sand casting. One such process is investment casting which uses a water-free ceramic mold at temperatures ranging up to 2000 F. These conditions are obviously unlike those of a green sand mold.

H. PRESENT is with Arwood Corp., Brooklyn, N.Y., and H. ROSENTHAL is with Frankford Arsenal, Philadelphia, Pa.

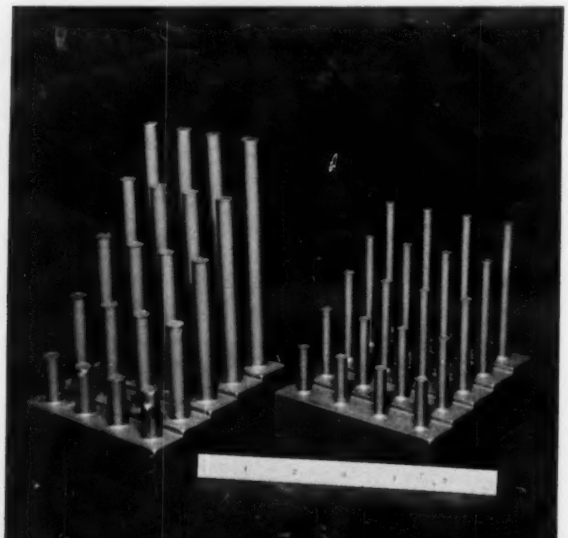


Fig. 1 — Wax patterns for ¼-in. and ⅜-in. bars of graduated length.

It was the purpose of this work to obtain feeding distance data which are applicable to these hot, dry, ceramic molds. It is realized that these data are by no means complete since they relate only to round bars. However, in the absence of other published data, it was felt that even this limited information might be useful to those interested in this field.

EXPERIMENTAL PROCEDURE

Figure 1 illustrates the design of the test castings for the ¼-in. and ⅜-in. bars. What is shown are wax patterns which eventually form the mold cavity. The mold, when ready for pouring, has the corresponding cavity with the bars vertically aligned and attached directly to the pouring basin. The basin acts as an infinite riser in feeding the bars.

The table lists the various bar parameters investigated. After casting, the bars were sawed off from the riser and radiographed. From the x-ray examination, it could be determined how long a given type of bar could be before it was affected by shrinkage. To make this determination, more than one bar was examined for each individual condition. The number of specimens ranged from two for the one in. bars to five for the ¼-in. bars.

BAR PARAMETERS INVESTIGATED

Bar Diameter, in.	No. of Bars Per Mold	Bar Length Increments, in.
¼	25	½
⅜	25	½
½	16	½
¾	9	½
1	4	1

Molds were prepared by standard processing techniques. The pre-dip slurry contained silica flour bonded by ethyl silicate. The backup investment consisted of coarser grades of silica bonded by magnesium pyrophosphate. Flasks were 5 in. square cans of stainless steel. After room temperature drying, the molds were fired 2 hr at 400 F (204 C); one hr at 700 F (371 C); 2 hr at 1100 F (593 C); and 8 hr at the final

mold temperature. For final mold temperature of 1200 F (649 C), it was necessary to heat at 1600 F (871 C) for 4 hr to complete oxidation of the wax residue before dropping the furnace back to 1200 F (649 C).

The steels were melted in a MgO lined, 50 kw, induction furnace. Ferrosilicon and ferromanganese were added to deoxidize the melt. Aluminum was added just before tapping. The metal was poured into a ladle prior to the final transfer to the molds.

To prevent wide variations in pouring temperature, not more than three molds were poured at one time. The maximum variation in pouring temperature was ± 15 F (8 C), as determined by an optical pyrometer. After pouring, exothermic hot top compound was applied to the molds. The molds were shaken out after air cooling to room temperature.

The bars were radiographed using a 220 kv unit with a 2.3 mm focal spot and 0.01 in. lead tube filter. Type M film was used at a distance of 48 in. from the focal spot; 0.005 in. lead screens were also used. Films were examined by a high intensity viewer.

RESULTS AND DISCUSSION

The effect of mold temperature (Fig. 2) was investigated on A.I.S.I. 1020 steel. Pouring temperature effects were determined on armco iron (Fig. 3). In addition, the effect of carbon content (Fig. 4) was studied with a fixed mold and pouring temperature. The three alloys of differing carbon content were armco iron, A.I.S.I. 1020 and A.I.S.I. 1095 steel. An addition of 0.1 per cent silicon was made to the armco iron to improve castability.

Adams[1] has pointed out that feeding distance will increase with increasing mold temperature if the section is uniform. From Fig. 2, it can be seen that there is little difference in feeding distance for molds at 1600 F (871 C) over molds at 1200 F (649 C). With molds at 2000 F (1093 C), there is a sizable increase of about one-third. It is probable that not all of this improvement with higher mold temperature is real since high mold temperatures tend to promote dispersed shrinkage. Although the sensitivity of the radiographic technique is about 1.5 per cent, detection of porosity is hindered by fine dispersion of the voids.

Figure 3 indicates that an increase in pouring temperature from 3000 F (1649 C) to 3300 F (1816 C) for armco iron more than doubled the feeding range. Here again, the dispersal of shrinkage may account for part of this increase.

The beneficial effect of carbon in feeding distance is shown in Fig. 4. The A.I.S.I. 1020 feeding distance is twice that observed with the armco iron, while the A.I.S.I. 1095 is almost three times that of the armco iron. These results must be interpreted in the light of Fig. 3, which illustrates the effect of pouring temperature, and against the fact that carbon depresses the freezing point of the steel. If the three alloys were compared on the basis of equal superheat pouring temperature, the feeding distances would be much more nearly alike.

In plotting maximum feeding distance against bar diameter, the data appeared to yield a simple linear relationship. These lines all converge toward the origin of the coordinate axes as might be expected.

Bishop, Myskowski and Pellini[2] have shown that, for green sand molds, there is a parabolic relationship between feeding distance and bar thickness. Their work was on a 0.25-0.35 carbon steel with bar sections varying from 2 x 2 in. to 8 by 8 in. The formula is

$$L = 6\sqrt{T}$$

where L is the maximum feeding distance.
T is the bar thickness.

This formula predicts a feeding distance of 6 in.

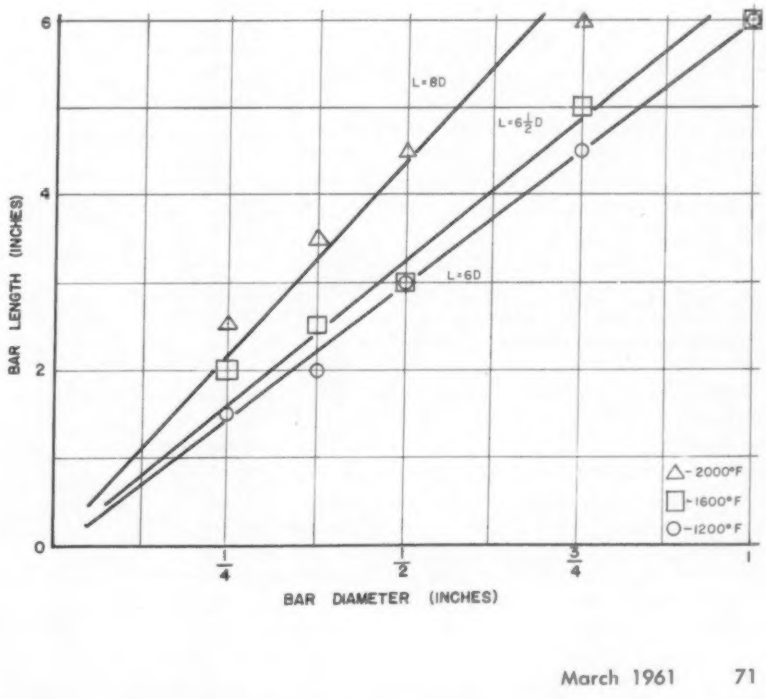


Fig. 2 — Mold temperature effect on A.I.S.I. 1020 steel. Pouring temperature, 3000 F (1649 C).

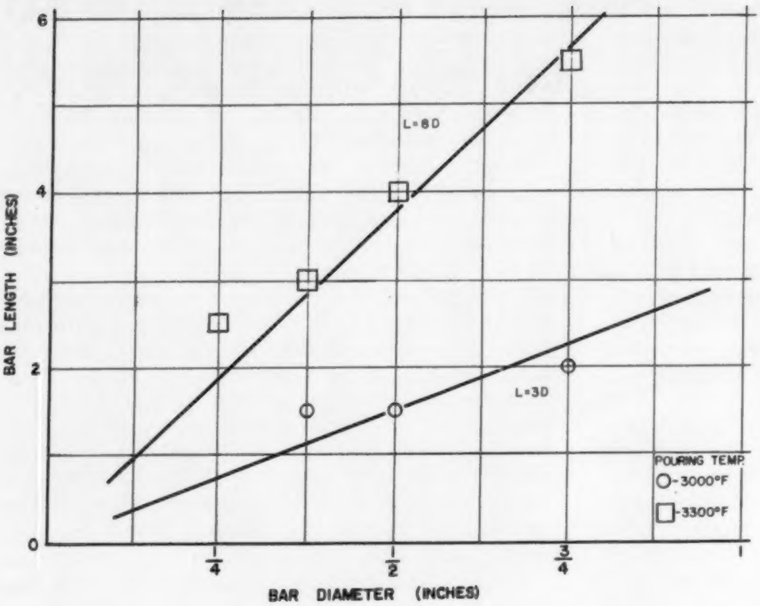


Fig. 3 — Pouring temperature effect on armco iron. Mold temperature, 1600 F (871 C).

for a one in. thick bar. Comparison can be made with Fig. 2, since the alloy is nearly the same. It can be seen that, for the 1200 F (649 C) mold temperature, the feeding distance is correctly predicted by the Pellini formula. However, the parabolic relationship does not hold for the smaller diameters.

CONCLUSION

With carbon steels, maximum feeding distance for round bars is increased by:

1. Higher mold temperatures.
2. Higher pouring temperatures.
3. Higher carbon content (for the same pouring temperature).

REFERENCES

1. C. M. Adams, "Gating and Risering of Investment Castings," *Metal Progress, vol. 69*, no. 5, p. 38 (May 1956).
2. H. F. Bishop, E. T. Myskowski and W. S. Pellini, "The Contribution of Riser and Casting End Effects to Soundness of Cast Steel Bars," AFS TRANSACTIONS, *vol. 59*, p. 171 (1951).

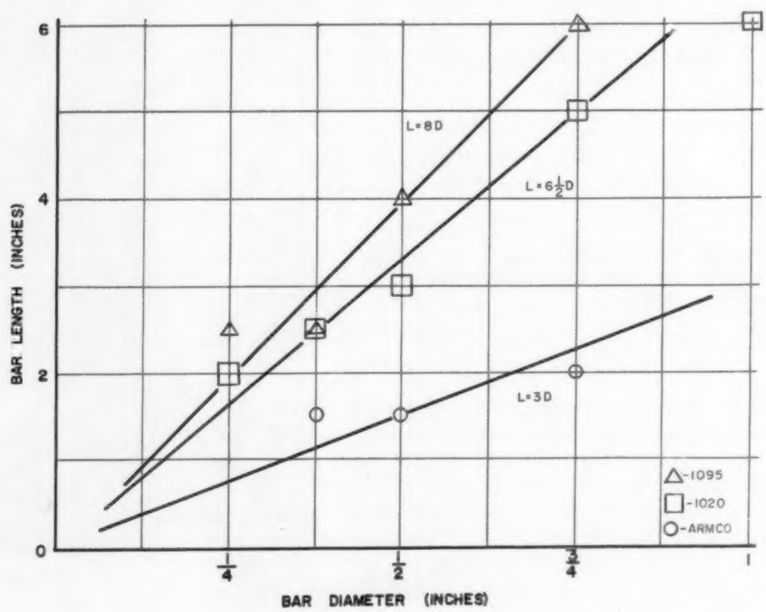


Fig. 4 — Alloy effect on feeding distance. Mold temperature, 1600 F (871 C). Pouring temperature, 3000 F (1649 C).

SYSTEMATIC APPROACH TO SAND DESIGN AND CONTROL

Progress report 4 — wood flour

by A. H. Zrimsek and G. J. Vingas

ABSTRACT

In the first three progress reports of this series, basic data were presented which described quite thoroughly the function of clay, water content and mulling on the physical properties of simply clay-sand-water systems.

Other than in non-ferrous shops, such simple systems are seldom used in normal foundry practice, but these systems serve as the basis of comparion for the more complex systems containing such ingredients as wood flour, cereal, seacoal, and silica flour. To understand the functions of these additives, it is necessary to first understand the base systems of sand, clay and water.

Using the first three progress reports as the basis of comparison, this report will deal with the effect of wood flour as a variable on the physical properties of clay-sand-water systems.

EXPERIMENT

The results and observations reported are based on data collected on 42 systems having different combinations of clay per cent, water per cent, wood flour per cent and mulling time. A total of 230 different sand mixes were studied.

SCREEN ANALYSIS OF BASE SAND USED

U.S. Standard Sieve No.	Retained, %
20	0.0
30	2.6
40	19.3
50	30.1
70	24.4
100	15.1
140	5.6
200	2.4
Pan	0.6

As in previous reports, a base sand, as described in the table, was used. All data were obtained from sands mulled in an 18 in. laboratory muller with a batch size of 4500 grams. Clay additions of 4.75, 7.45 and 10 per cent for bentonite and 10 or 15 per cent for fireclay were made. At each clay content, additions of wood flour in amounts of 0.75, 1.5 and 3.0 per cent were added. With each clay-wood flour combination at least five different water contents were used.

The mixture was dry mulled 15 sec, water was added, and the mixture wet mulled for 2, 4 and 6 min. The sands produced were placed in airtight polyethylene bags. Green testing was done immediately and dry testing done after specimens had been oven dried at 220-230 F for periods not less than 5 hr. Data were collected on specimens rammed at 1, 3, 5, 7 and 10 rams.

RESULTS

As in previous reports of this series, results are plotted graphically. The extremely large volume of data collected, if presented in its entirety, would require 84 pages of graphs such as Figs. 1-6b. Presentation of the total data would not only be unwieldy and confusing, but is actually not required to demonstrate the principles involved. The data omitted, however, do support the conclusions to be drawn, but are repetitive.

DISCUSSION

The function of wood flour additions to foundry sands, according to popular opinion, is to increase green strength, lower dry strength and improve flowability. This conception, although often true in practical application, is a bit over-simplified.

In the initial three reports of this series, the effect of water content on green and dry properties of clay-sand mixtures was established. In Figs. 1, 4 and 11, several of the systems of those reports are reproduced. Figures 1a-1d depict the effect of 0, 0.75, 1.5 and 3.0 per cent wood flour additions on the 4.75 per cent western bentonite system. It is noted that the main effect of increasing wood flour addition is to shift the peak strength point to positions of higher water.

Although the general strength level of the curves is shifted upward slightly, the main cause of increased green strength with increased wood flour additions is caused by the shift of the entire curve to positions of higher water. The curves for green shear and density also shift to positions of higher water content. An examination of Figs. 2a and 2b shows similar effects

A. H. ZRIMSEK is Fdy. Engr. and G. J. VINGAS is Rsch. Engr., Magnet Cove Barium Corp., Arlington Heights, Ill.

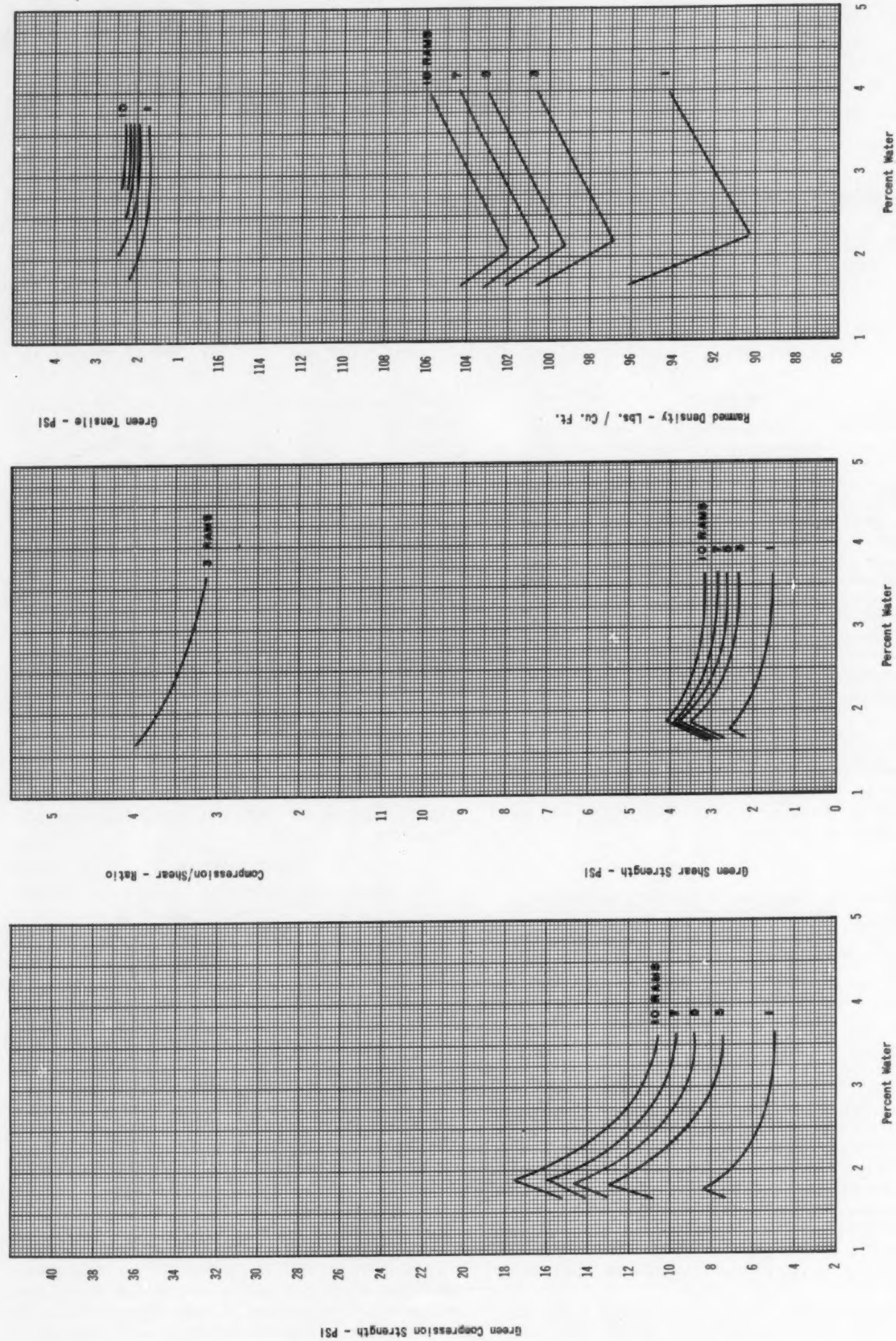


Fig. 1a — Water content and ramming energy effect on physical properties of 4.75 per cent western bentonite bonded Portage silica sand. Mulled 6 min.

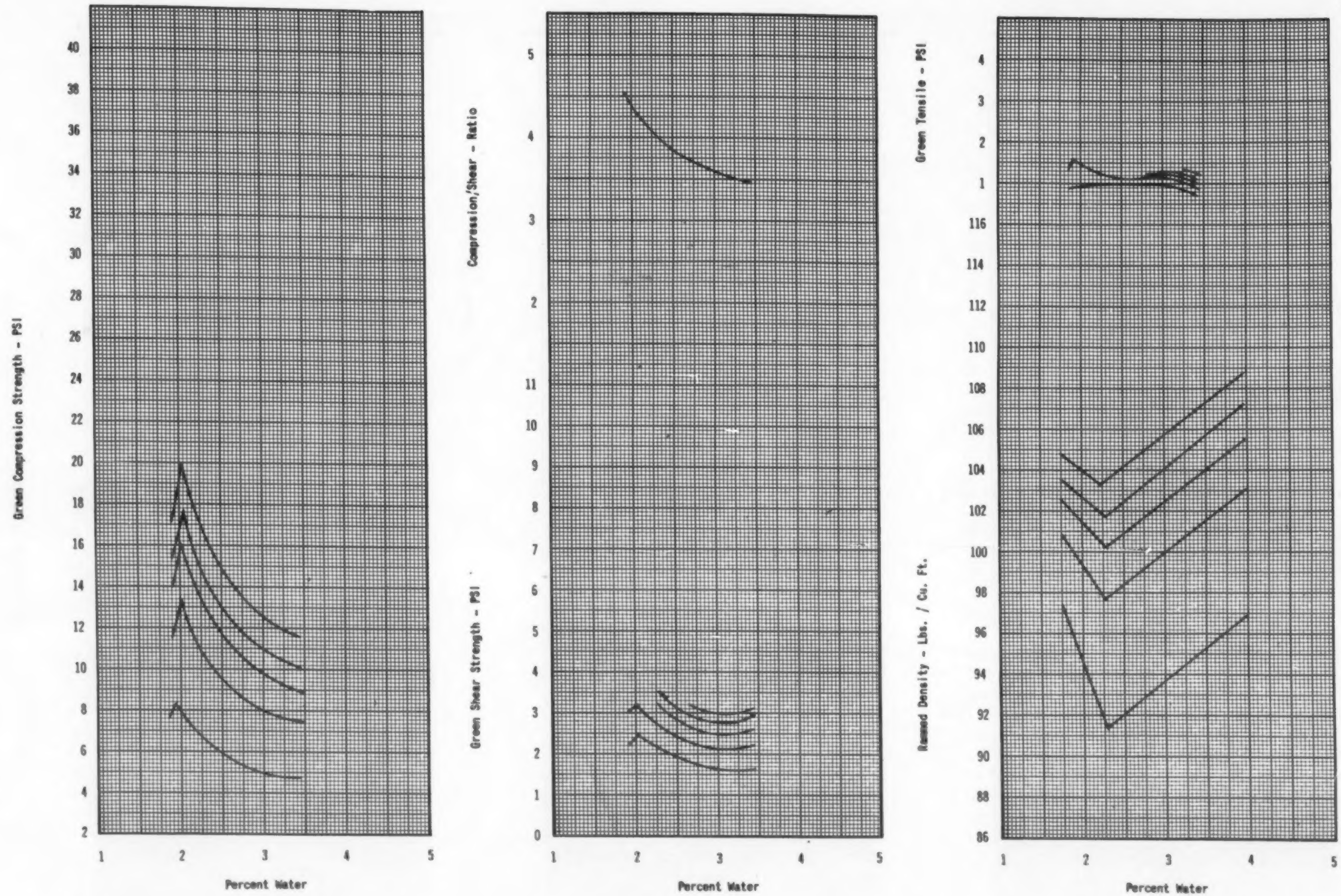


Fig. 1b — Water content and ramming energy effect on physical properties of 4.75 per cent western bentonite, 0.75 per cent wood flour bonded Portage silica sand. Mulled 6 min.

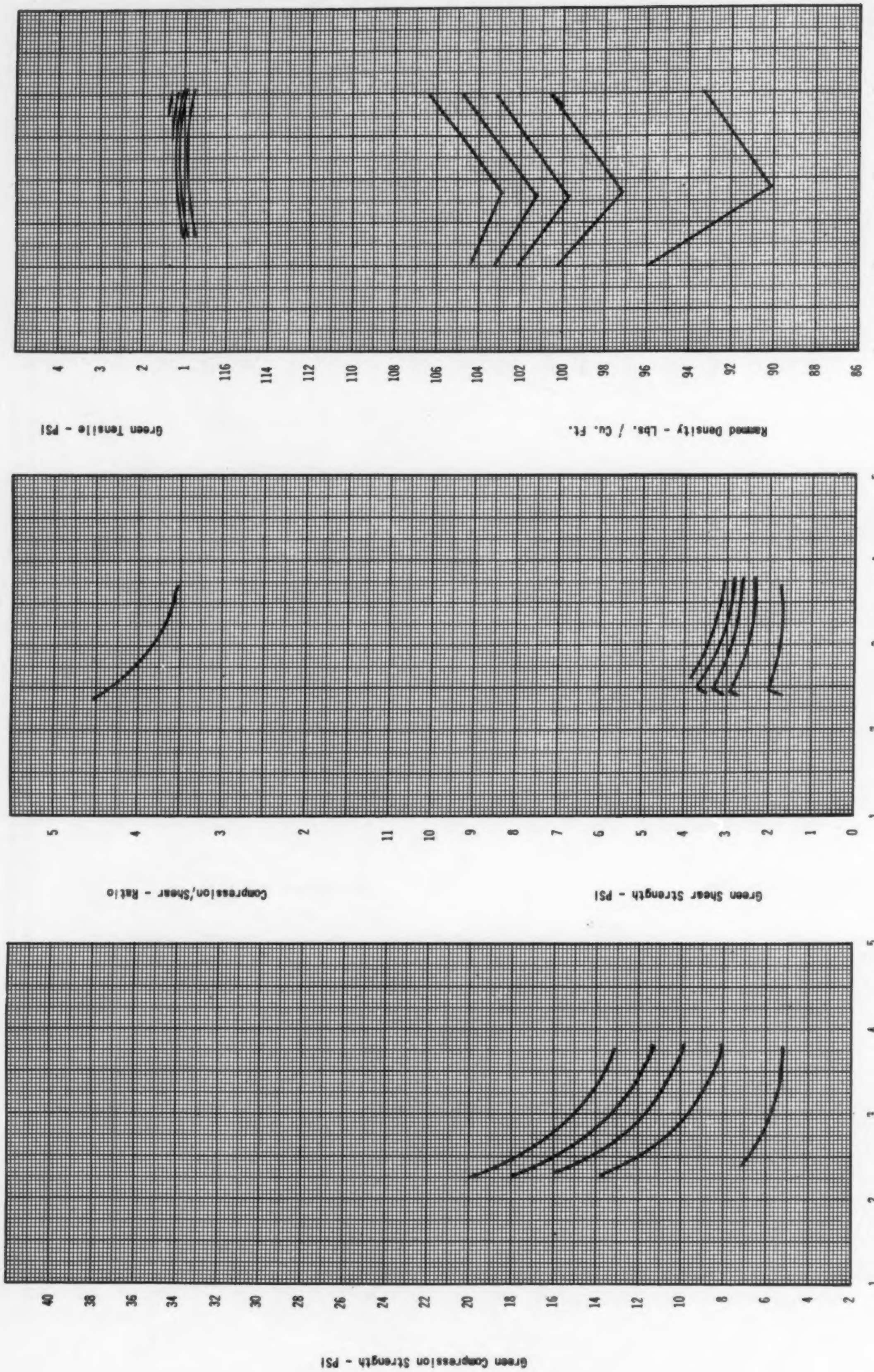


Fig. 1c — Water content and ramming energy effect on physical properties of 4.75 per cent western bentonite, 1.5 per cent wood flour bonded Portage silica sand. Mulled 6 min.

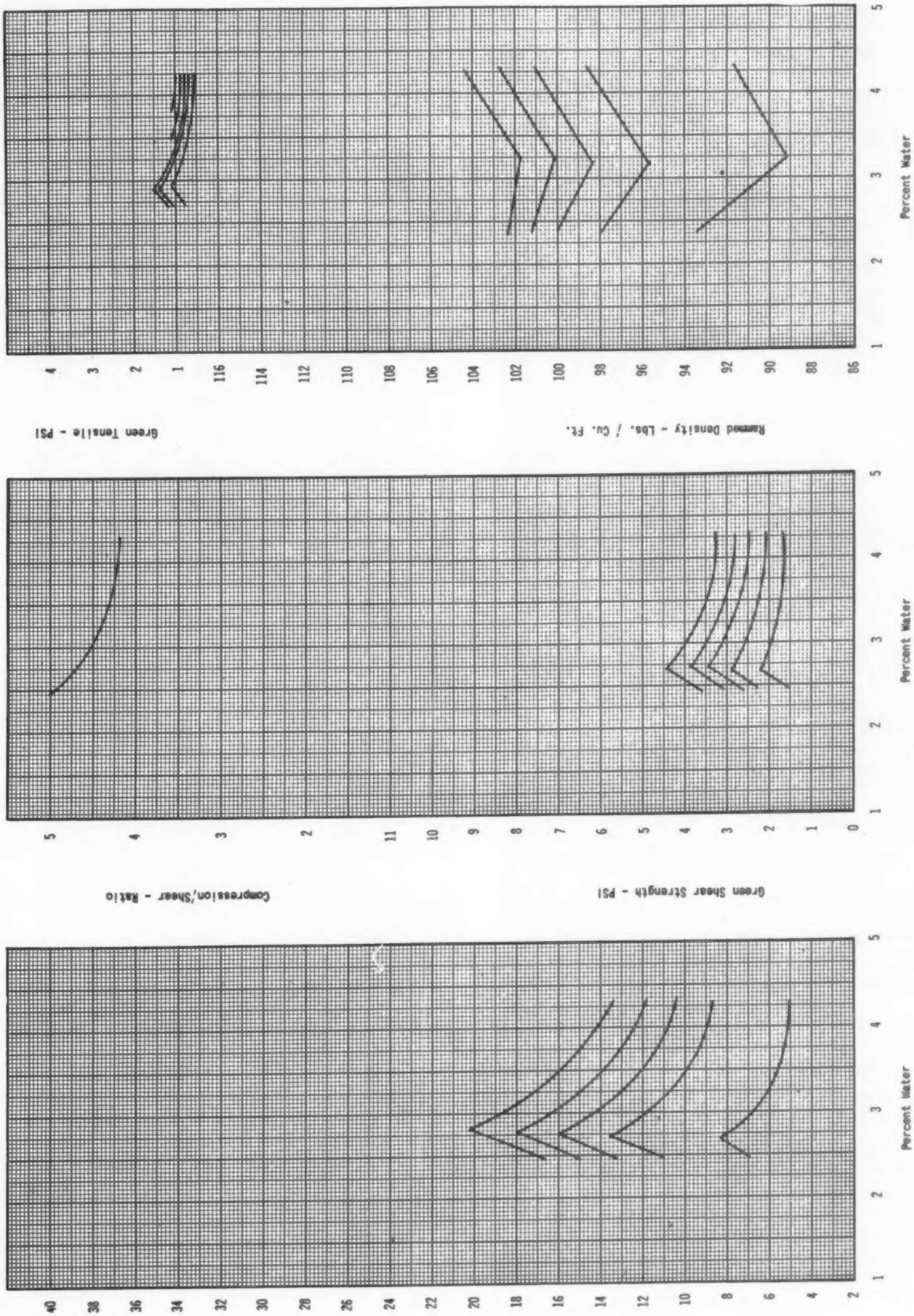


Fig. 1d — Water content and ramming energy effect on physical properties of 4.75 per cent western bentonite, 3 per cent wood flour bonded Portage silica sand. Mulled 6 min.

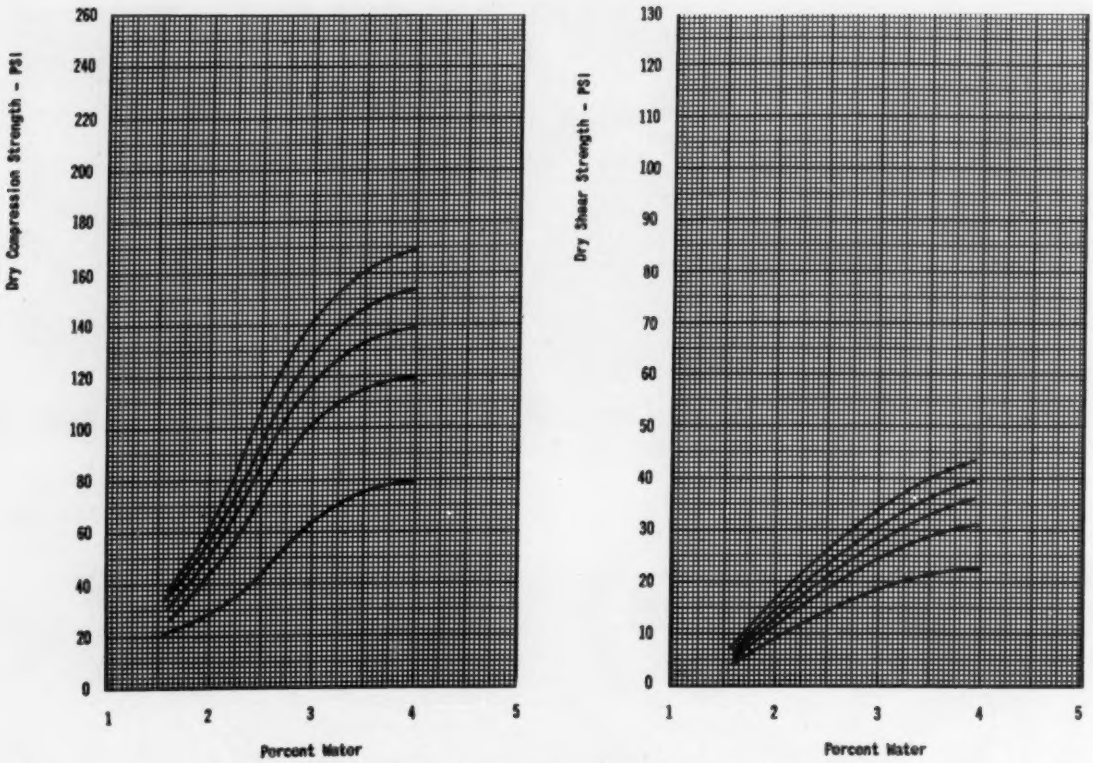


Fig. 2a — Water content and ramming energy effect on physical properties of 4.75 per cent western bentonite bonded Portage silica sand. Mulled 6 min.

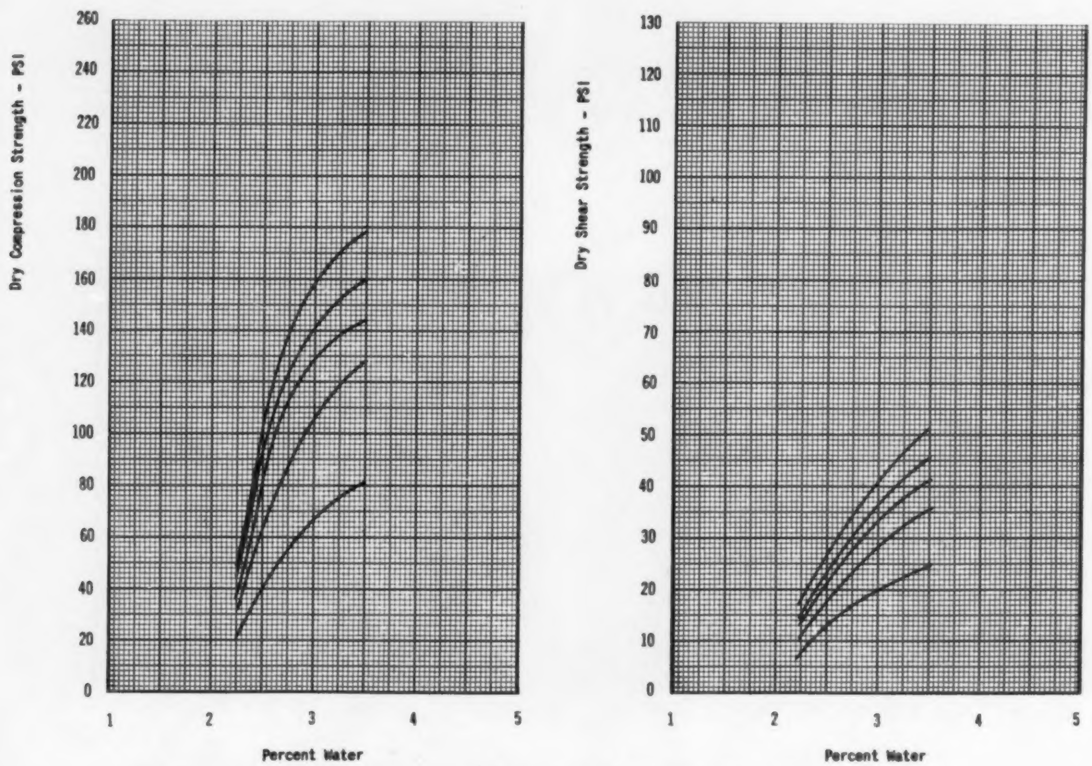


Fig. 2b — Water content and ramming energy effect on physical properties of 4.75 per cent western bentonite, 0.75 per cent wood flour bonded Portage silica sand. Mulled 6 min.

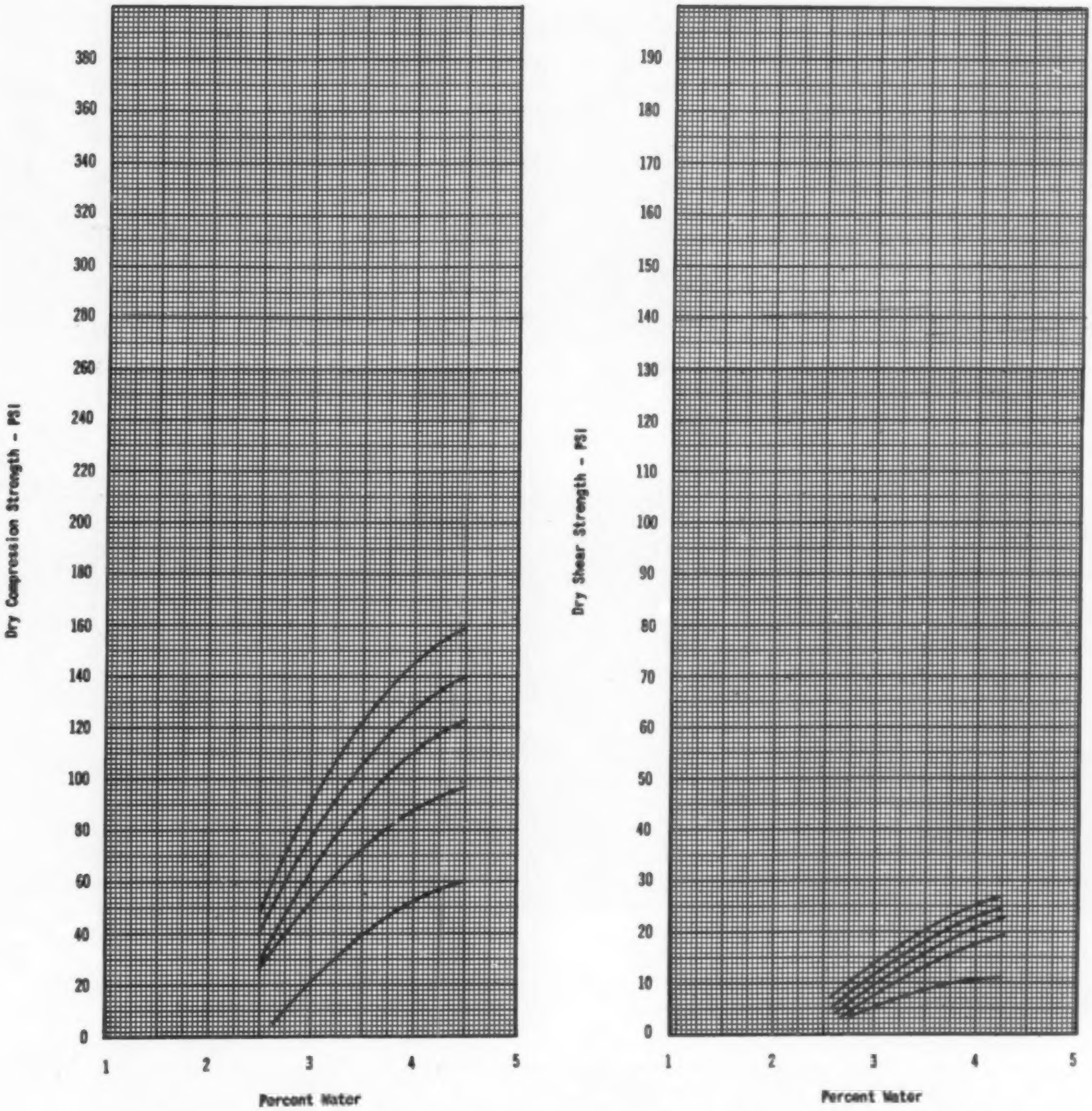


Fig 2c — Water content and ramming energy effect on physical properties of 4.75 per cent western bentonite, 3 per cent wood flour bonded Portage silica sand. Mulled 6 min.

for dry properties. Of course, if water and clay content are held constant while wood flour additions are increased the effect is one of drying the sand, and thereby increasing green and reducing dry compression.

It would seem that a similar reaction can be had by simply reducing water content. This again is oversimplification. If green and dry compression in themselves were capable of describing sand quality, simple reduction in water content would have the same effect as holding water constant and increasing wood flour additions, but such is not the case. While the relationship of green compression to dry compression for western bentonite bonded sands is almost unaffected by wood flour additions, dry shear and the relationship of green compression to green shear are changed substantially.

Comparison of data depicted in Figs. 2a-2b and 3a-3b shows that while dry compression values are simply shifted to points of higher water content, dry shear values are not only shifted to higher water content but actually lowered with increasing wood flour additions.

Wood Flour Effect on Southern Bentonite Bonded Sands

Southern bentonite bonded sands are more severely affected by wood flour additions. While the dry com-

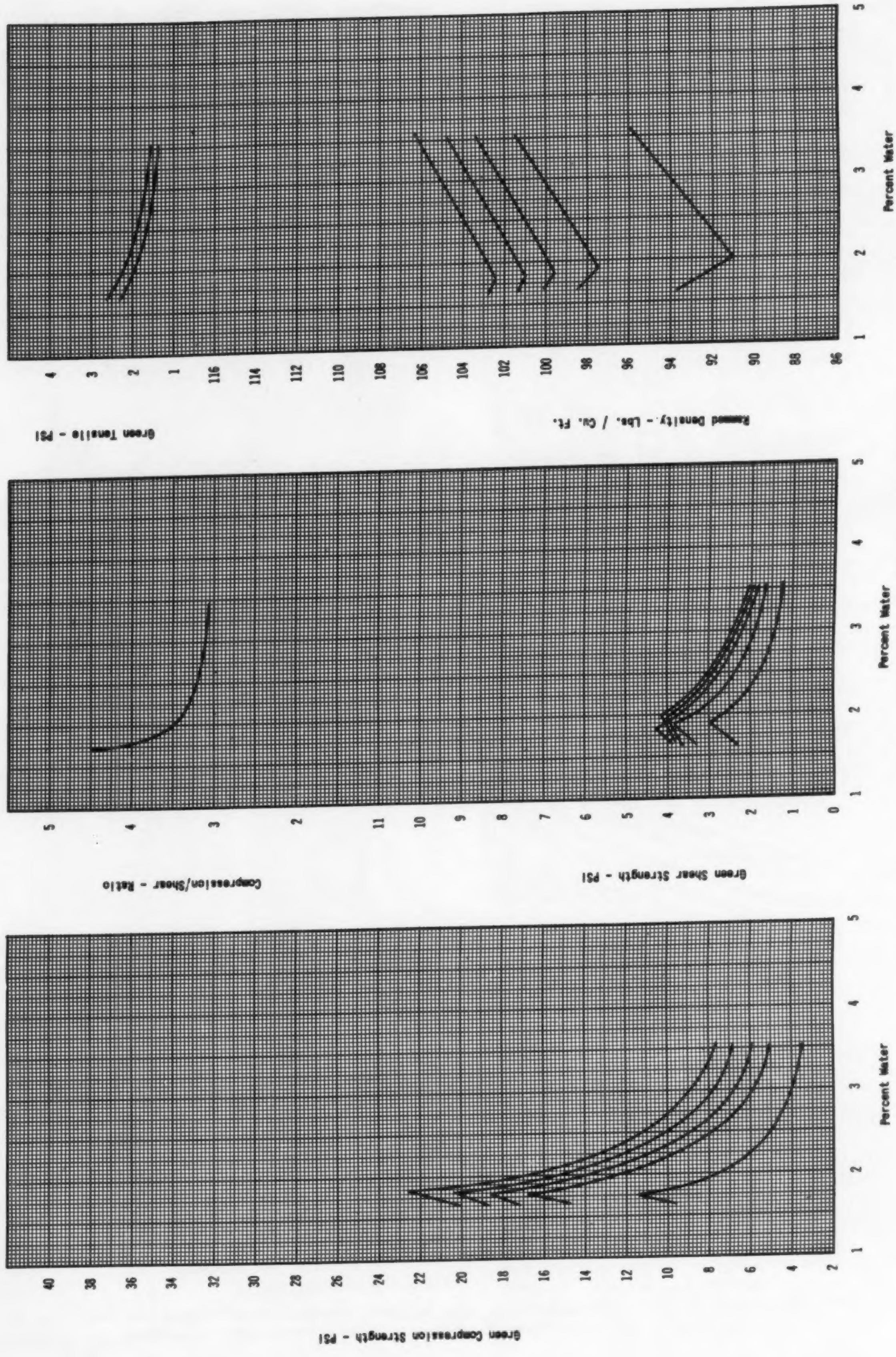


Fig. 3a — Water content and ramming energy effect on physical properties of 4.75 per cent southern bentonite bonded Portage silica sand. Mulled 6 min.

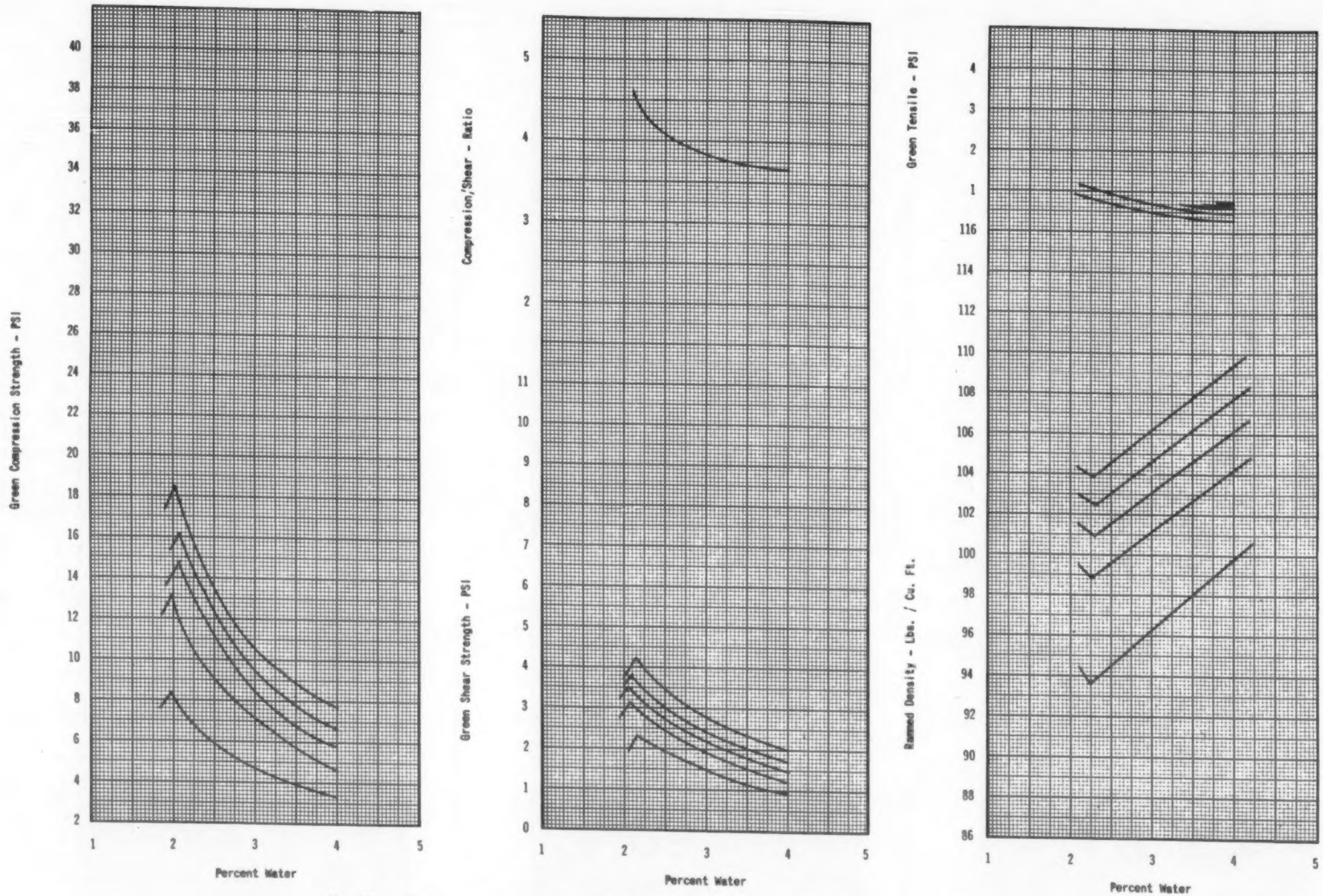


Fig. 3b — Water content and ramming energy effect on physical properties of 4.75 per cent southern bentonite, 0.75 per cent wood flour bonded Portage silica sand. Mulled 6 min.

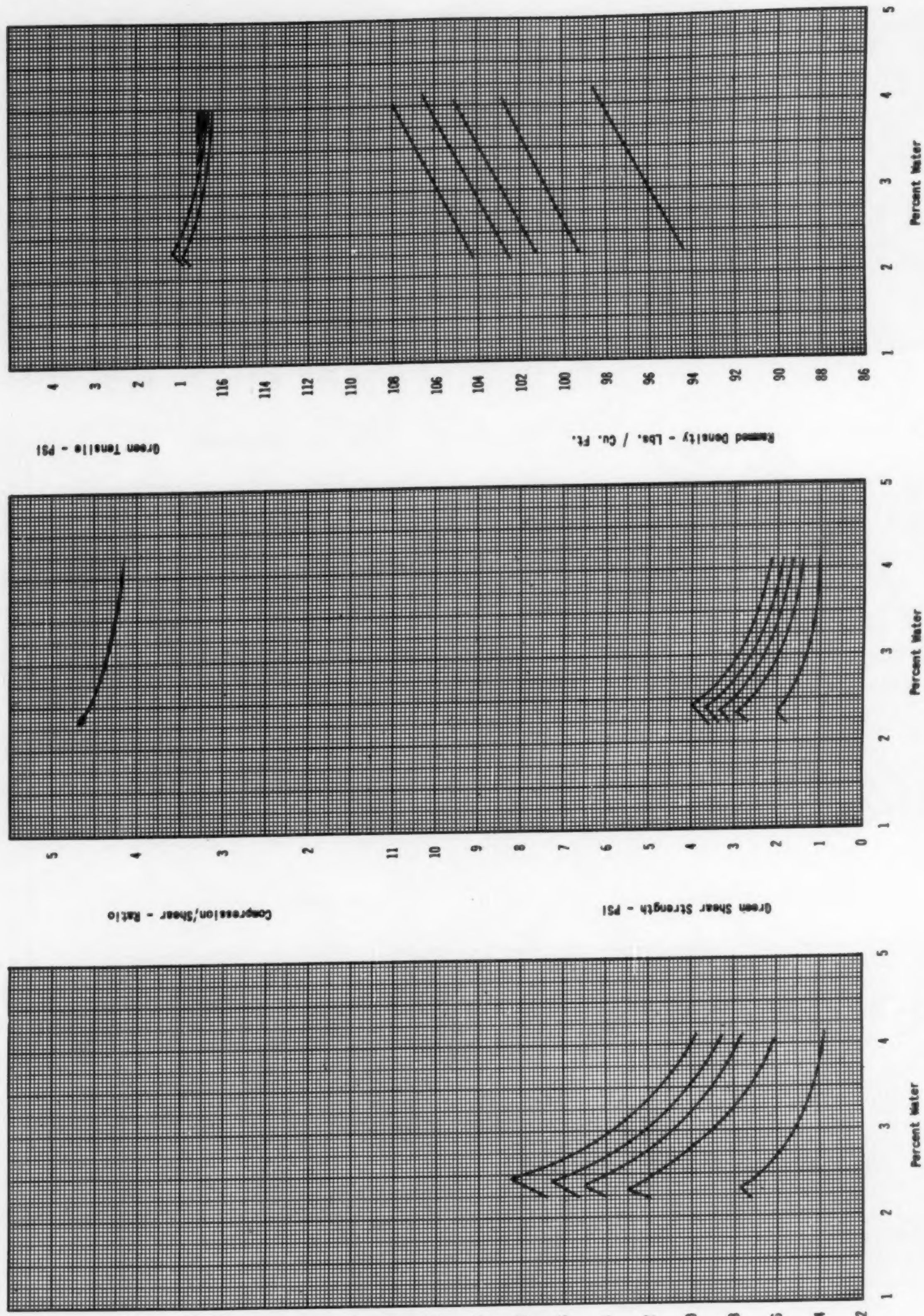


Fig. 3c — Water content and ramming energy effect on physical properties of 4.75 per cent southern bentonite, 1.5 per cent wood flour bonded Portage silica sand. Mulled 6 min.

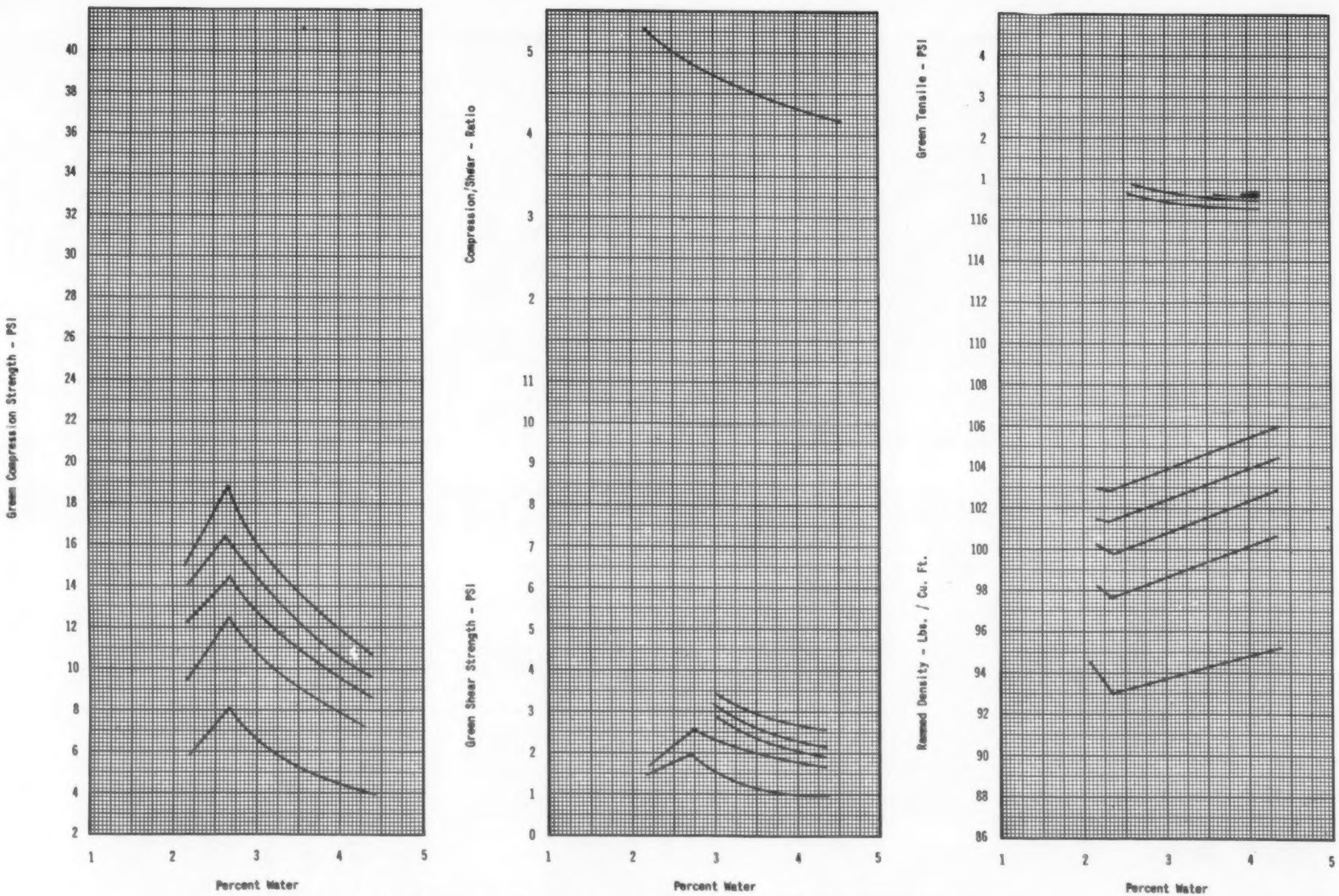


Fig. 3d — Water content and ramming energy effect on physical properties of 4.75 per cent southern bentonite, 3 per cent wood flour bonded Portage silica sand. Muiled 6 min.

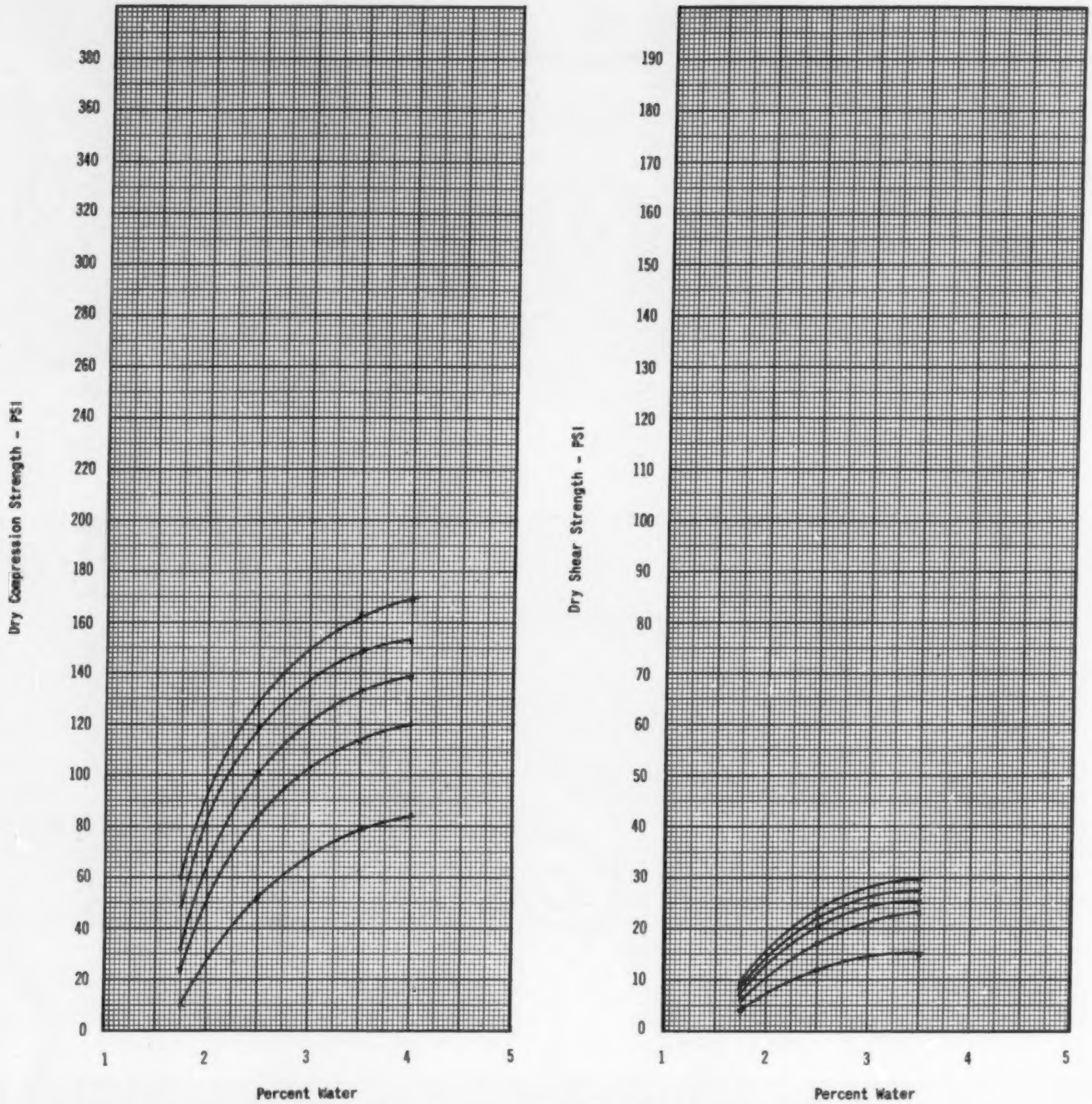


Fig. 4a — Water content and ramming energy effect on physical properties of 4.75 per cent southern bentonite bonded Portage silica sand. Mulled 6 min.

pression strength characteristics of western bentonite bonded sands remain relatively unchanged by wood flour additions up to 3 per cent, both dry compression and shear are drastically lowered by wood flour additions. The effects of wood flour on physical properties of southern bentonite bonded sands are presented in Figs. 3a-3d and 4a-4b.

It will be recalled from earlier progress reports of the series that reference was made to the ratio of green compression to green shear. In the accumulation of data for the series, it has been a significant observation that sands which are wet and tough to the feel, and which would be described by most foundrymen as lacking flowability, have a compression to shear ratio that is near 3:1. It has been observed that this 3:1 ratio can be obtained with any clay-sand mixture through use of high water contents.

Brittle sand can be had from any clay-sand mixture simply by reducing the water content. As water content is reduced, the ratio is raised to between 4:1 and 6:1. One of the main difficulties encountered with simple bentonite-sand mixtures is that the shift from brittle to wet and plastic takes place over a narrow range of water. The water control required

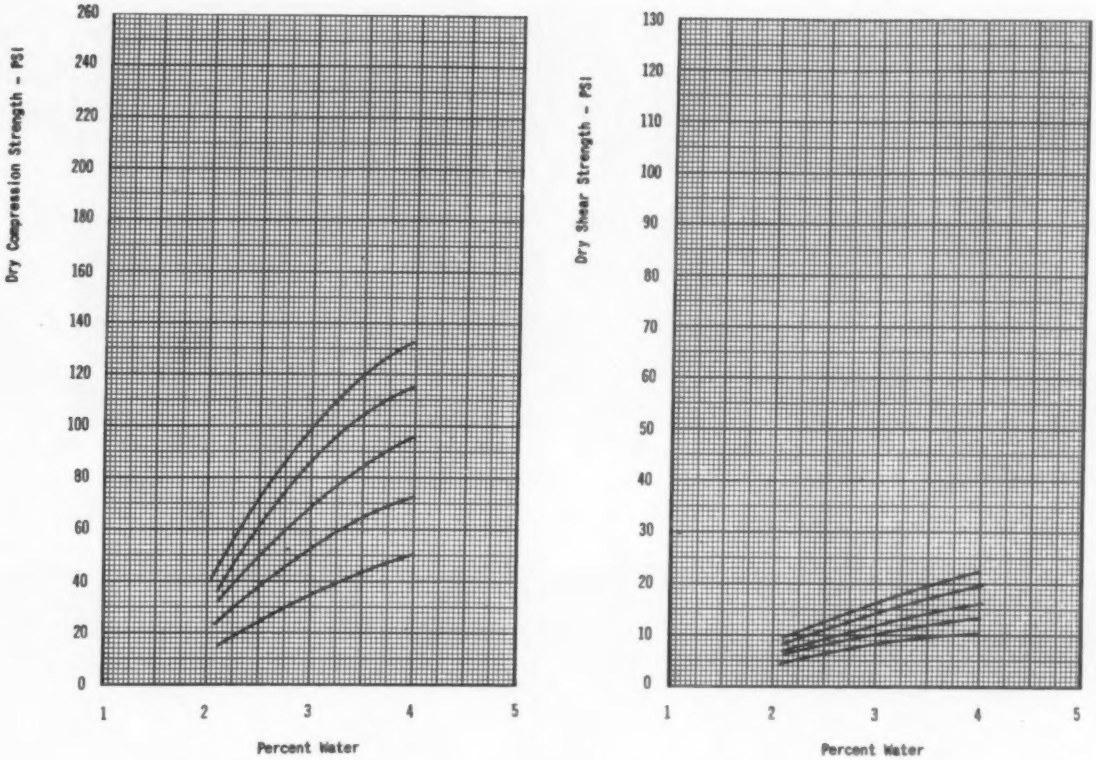


Fig. 4b — Water content and ramming energy effect on physical properties of 4.75 per cent southern bentonite, 0.75 per cent wood flour bonded Portage silica sand. Mulled 6 min.

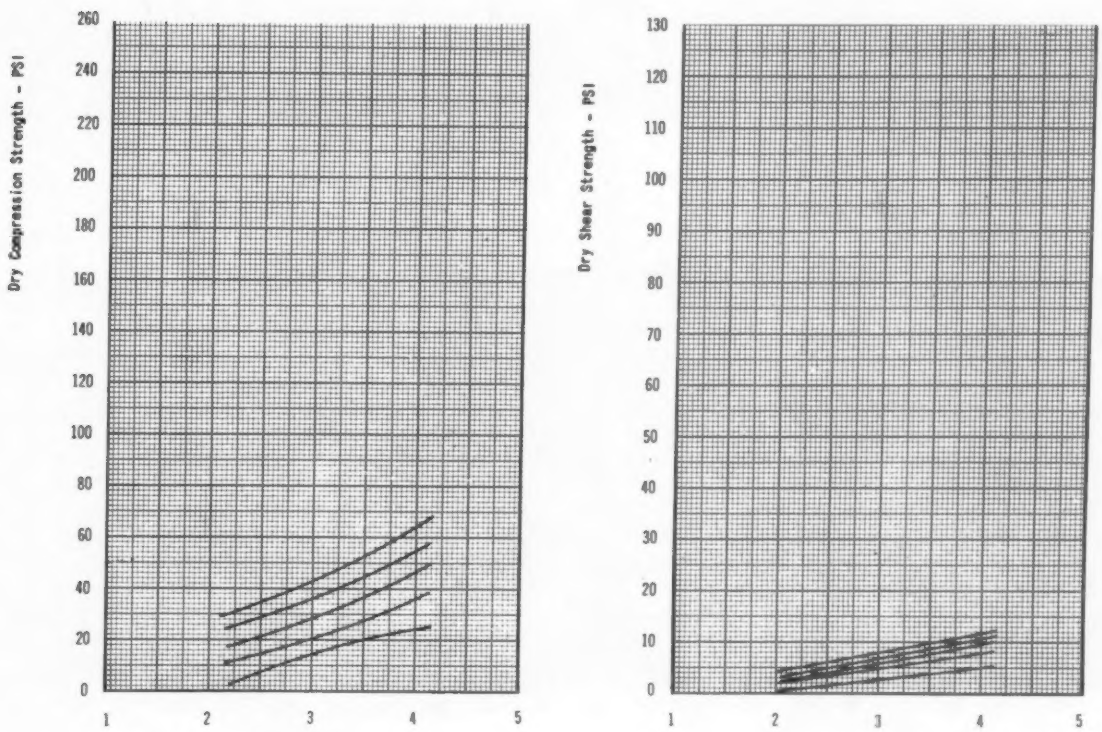


Fig. 4c — Water content and ramming energy effect on physical properties of 4.75 per cent southern bentonite, 3 per cent wood flour bonded Portage silica sand. Mulled 6 min.

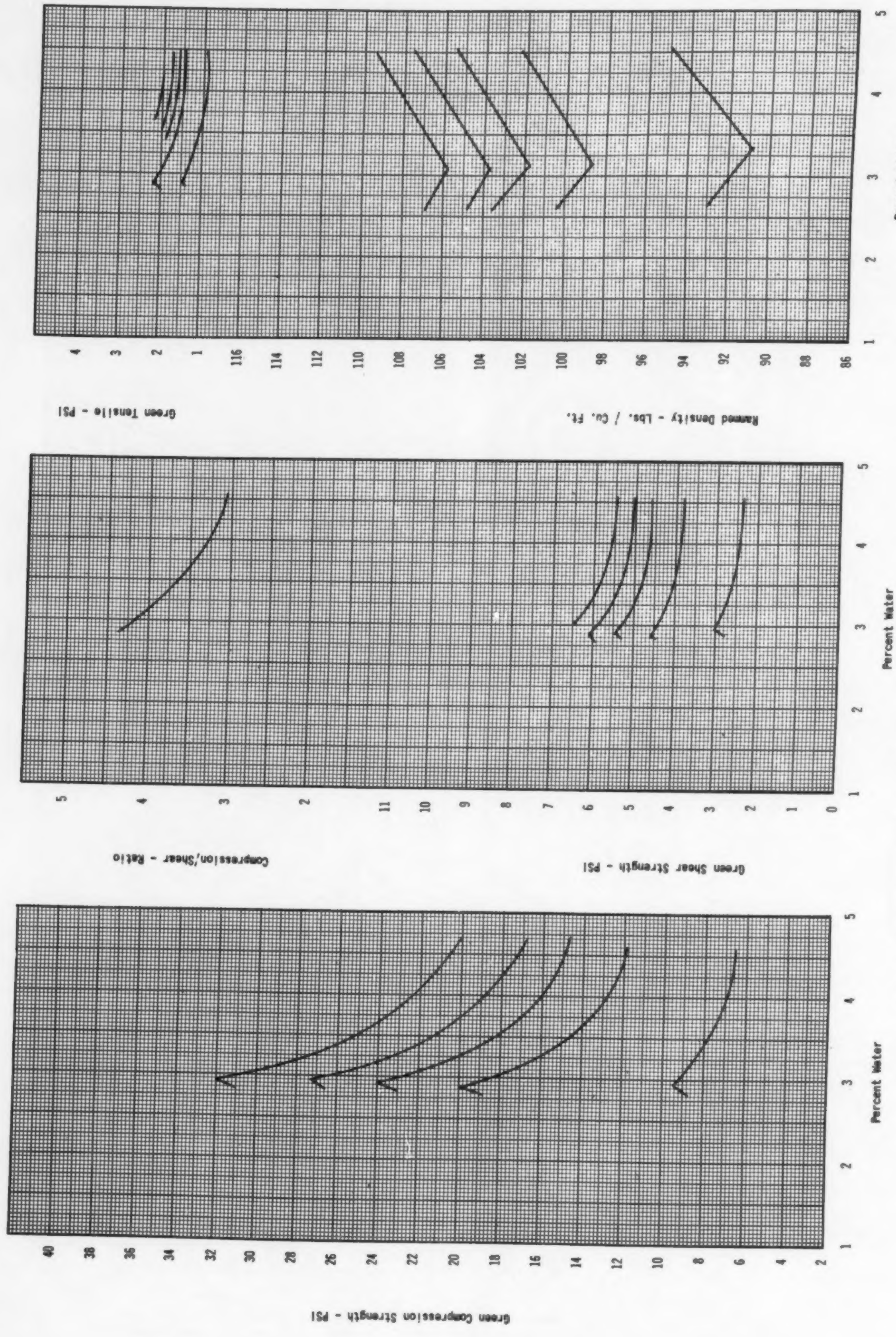


Fig. 5 — Water content and ramming energy effect on physical properties of 7.45 per cent western bentonite, 0.75 per cent wood flour bonded Portage silica sand. Mulled 6 min.

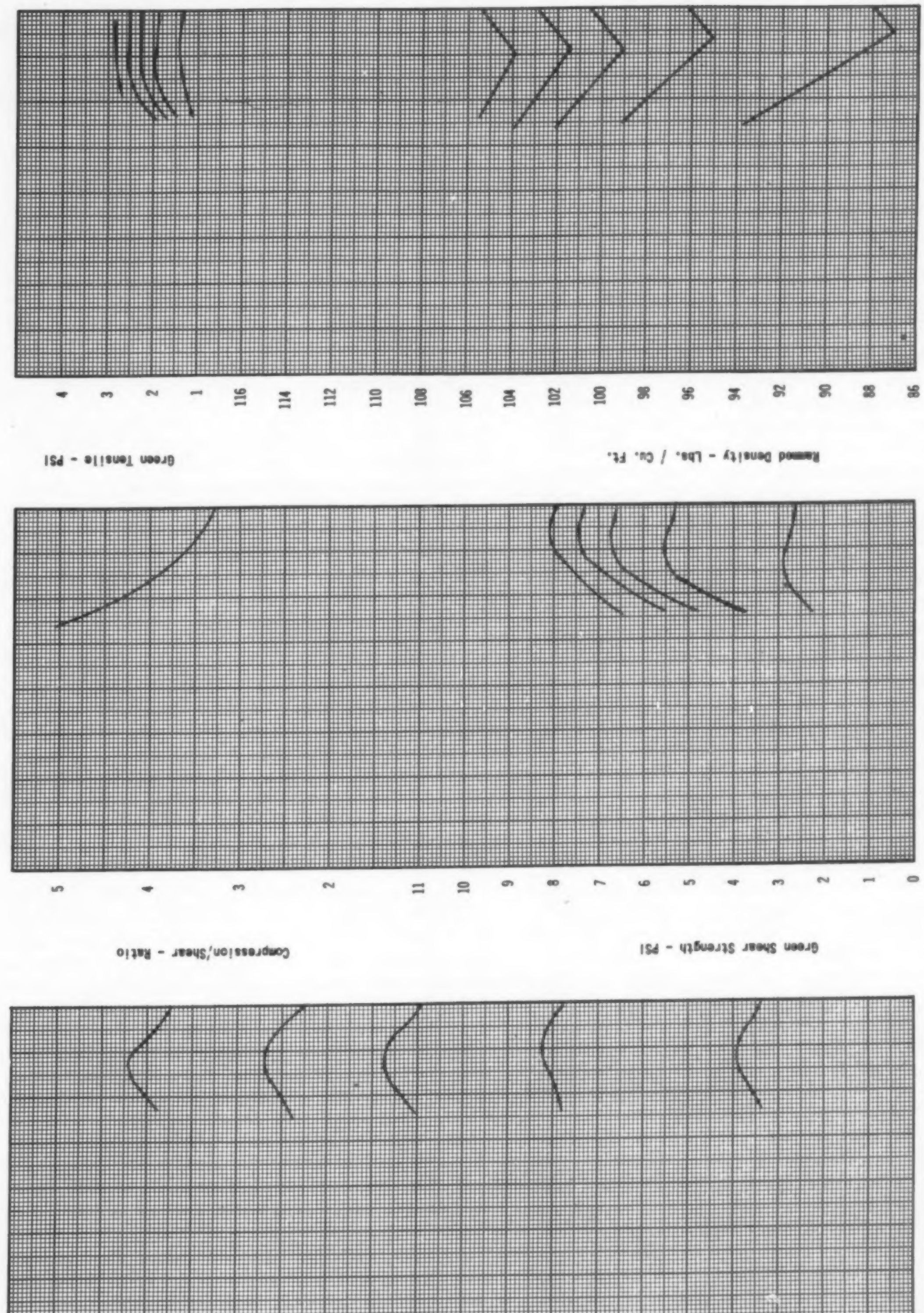


Fig. 6 — Water content and ramming energy effect on physical properties of 10 per cent western bentonite, 3 per cent wood flour bonded Portage silica sand. Mulled 6 min.

to produce a sand that is neither too brittle nor too plastic, while not impossible, is outside the realm of practicality for most foundries.

This is one of the major shortcomings of bentonites. One of the major functions of wood flour in new clay-sand mixtures is to widen this range of water content in which optimum plasticity occurs. These experiments have shown to the satisfaction of the authors that the best molding conditions for sands occur when the ratio of compression to shear is in the range of 3.75:1 to 4.5:1. This is not to say that sands of this nature necessarily produce the best castings, but that they do produce high density molds with a combination of the least amount of effort and least amount of breakage.

Wood Flour Function

As an example of the function of wood flour, consider the system containing 4.75 per cent southern bentonite. Examination of Fig. 3a, which depicts the simple 4.75 per cent southern bentonite-sand-water systems, shows that a control of water content between 1.7 and 1.85 per cent would be required to maintain sands with a compression to shear ratio between 3.75:1 and 4.5:1. Through the addition of 0.75 per cent wood flour, the 3.75:1 to 4.5:1 range can be maintained with water contents between 1.9 and 3.25 per cent. With a 1.5 per cent wood flour addition, the allowable water range is stretched from 2.6 to about 5.0 per cent.

Increase in wood flour to 3 per cent simply produced sands which are brittle (ratio of compression to shear above 4.5:1) over the major portion of the water range. Water contents in excess of 3.5 per cent are required to obtain sands which are not excessively brittle. Wood flour has a similar though not as drastic effect on western bentonite bonded sands, as can be seen in Figs. 1a-1d.

Fireclay-sand mixtures without wood flour additions experience only moderate change in toughness with increasing water content and resemble quite closely the bentonite-wood flour-sand mixtures. Wood flour additions to the fireclay bonded sands simply move the working range to higher water contents.

While wood flour has a potent effect on bentonites at the 4.75 per cent level, its effect at the higher levels of 7.45 and 10 per cent is small. Addition of 0.75 per cent wood flour to sand mixtures containing 7.45 and 10 per cent western or southern bentonite mulled 6 min did not change either feel or the mechanical properties to any perceptible degree. This is shown in Fig. 5. At the level of 1.5 per cent wood flour, sands which were bonded with 7.45 per cent bentonite were affected moderately, but those bonded with 10 per cent were only slightly affected.

Additions of 3 per cent wood flour were required before the plasticity of 10 per cent bentonite bonded sands was highly affected. In general, southern bentonite bonded sands were modified to a greater degree by wood flour additions than were western bentonite bonded sands.

Mulling Time Effects

Although this project included an extensive study of muller effects on wood flour containing sands, the data at 2 and 4 min mulling time are quite erratic and do not lend themselves to intelligent discussion. Even at 6 min mulling time, data collected at the higher bentonite levels of 7.45 and 10 per cent together with 1.5 and 3.0 per cent wood flour were erratic. From the shape of the curves, as shown in Fig. 6, these data indicate a condition of undermulling.

This is similar to the condition expected from a simple western bentonite bonded sand mulled only 2 min. In no instance, regardless of clay type or per cent and wood flour per cent, was 2 min mulling adequate to break up localized clusters of wet wood flour. In many instances wet wood flour clusters persisted to 4 min mulling and beyond. As a result, data collected throughout the project were less predictable than the data collected on simple clay-sand-water systems and presented in earlier progress reports of this series.

In the earlier reports on clay-sand systems, data presented are exact, and the graphical representations are drawn through actual plots of data. In the present report, graphical representations are the best lines which could be drawn through the plotted data. The data of this report would best be represented by bands 5 per cent from the lines drawn, but is presented in the manner shown to avoid confusion.

CONCLUSIONS

The reader is reminded that the data presented were gathered on new sand mixtures.

The addition of wood flour to clay-sand-water systems does not in reality lower dry compression strength of western bentonite bonded sands. It simply increases the water content required to obtain a given dry compression level. In a similar manner, green compression strength is not increased perceptibly. Only the water content required to obtain a given green compression strength is increased.

Dry compression strengths of southern bentonite sands, on the other hand, are drastically reduced by wood flour additions. Green shear and dry shear strengths of both western and southern bentonite bonded sands experience a drop with increasing wood flour additions. Low clay content sands are affected more by wood flour additions than high clay sands.

While simple bentonite-sand-water systems experience drastic change from brittle to plastic with small change in water, the same combinations with wood flour added experience the change from brittle to plastic over a substantially wider range of water content. Simple fireclay bonded sands exhibit this property, and additions of wood flour did not influence this water range except to shift it to higher water levels.

Difficulty in eliminating wet wood flour clusters through mulling was increased by wood flour additions, and, in general, presence of wood flour retarded mulling action.

ACKNOWLEDGMENT

The writers wish to thank Magnet Cove Barium Corp. for permitting them to spend the necessary time to gather these data and publish the results based on interpretation of the data.

MACHINED PATTERNS CAN BE COMPETITIVE

by Ray Olson

ABSTRACT

The all machined metal pattern can be competitive to patterns made from some of the newer materials, according to the author. It is up to the pattern shop to adopt time saving methods so these patterns may be produced in a faster, less expensive and more accurate fashion. The resulting end product will be one which will outlast some of the patterns made in newer products.

INTRODUCTION

Revolutions in the foundry industry have been occurring at a steadily increasing rate during the past generation. This is particularly true in the field of patternmaking. It is said that some good comes from even the worst of revolutions. Many of those which have exploded on the pattern scene have offered some benefits.

Newly developed synthetic materials to replace wood and metal have elbowed into a firm place in the pattern picture. Precision casting techniques to produce metal patterns to close tolerances in the as-cast condition have appeared on the scene. More recently emphasis has been placed on new and old processes for depositing metal to build up or actually create a metal pattern. All of these are considered revolutionary in nature.

Everyone is interested in this type of development. This includes, of course, those who buy patterns. Too often the foundry is the last place in the manufacturing picture to receive money and attention. In the foundry, patterns are considered a necessary evil. The time necessary, and cost required to produce a good pattern have always been reluctantly tolerated. So when a revolution comes along that will tend to eliminate, in a large sense, the patternmakers, customers hop on the bandwagon. Needless to say, cure-alls do not always work and again patterns are a necessary evil.

METAL PATTERN EQUIPMENT

Let us give the same energy and attention now directed at new processes to the old way. By old way, machined production metal pattern equipment is meant. For a good solid production pattern that can be readily checked, repaired and maintained, nothing can beat an all machined job. This article does not refer to those patterns which, due to size or production requirements, are more practically made from other materials.

Progress might better be considered using the stand-

R. OLSON is Vice-Pres., Southern Precision Pattern Works, Inc., Birmingham, Ala.

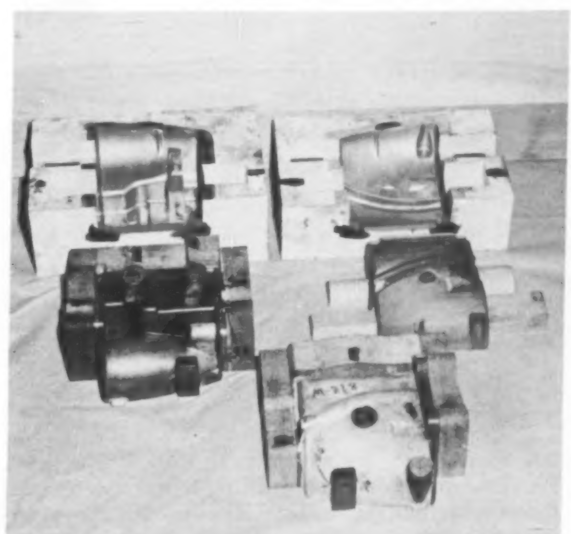


Fig. 1a — A set of pattern and core box duplicating models, with original hardwood core dummy are made from hardwood, plastic and hard plaster.

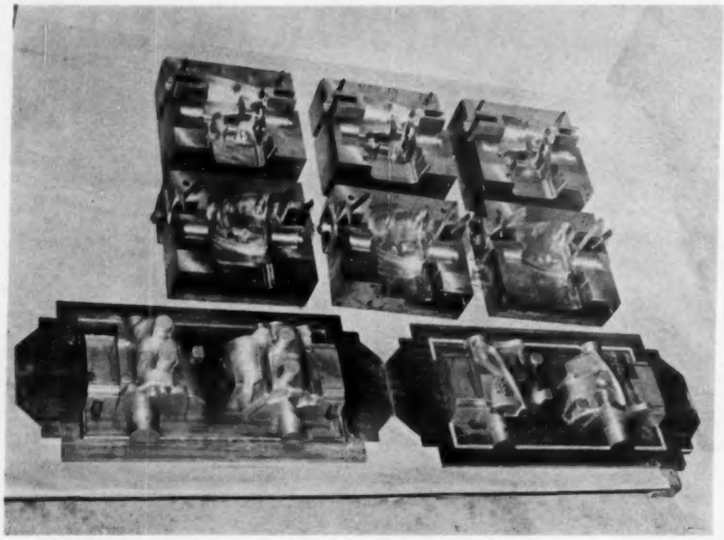


Fig. 1b — A set of three duplicate shell core boxes and two mounted patterns made from the models illustrated.

ard time proved pattern materials processed in a faster, cheaper, more accurate method. Many developments in the art of stock removal or machining have come into widespread usage. In most cases, however, it is not the pattern shops that take advantage of those developments. They are too busy trying to learn all about these revolutionary developments to improve on established techniques.

The major cost and time requirements of producing all machined metal patterns can be drastically reduced. First, let us look at how this job has been done. Depending upon the degree of complexity, many trips have been required between layout, machine and bench for such a pattern. By pattern, any portion or type of pattern equipment is meant. Pattern or core box castings would go through rough layout. Then some flat surfaces and heights would be machined. Back then to layout to prepare for secondary machining operations.

In some cases bench operations, such as template fitting, could occur before secondary machining. After secondary machining, such as vertical surfaces and other operations determined by that second trip to the Layout department, this equipment would make a third trip to layout and subsequently to the machines. The foregoing, in a general sense, typifies what has been considered standard pattern machining practice. In complicated jobs this step-by-step operation sequence can be repeated at least six times before the equipment is ready for final bench hand work.

PATTERN PRODUCTION COSTS

That has been the problem. In the operations just described lie most of the cost of producing this type of pattern equipment. This is triply painful. The cost is increased to a point where the revolutionary processes are taking over with a substantial loss of business for some of the pattern shops. Second, the time requirements are such that pattern customers, the ever impatient pattern buyers, cannot wait. Last, but certainly not least, is the drain on pattern shop skills. The caliber of patternmakers required—layout men, machinists and bench men, for this method is severe due to the constant mental and manual dexterity involved.

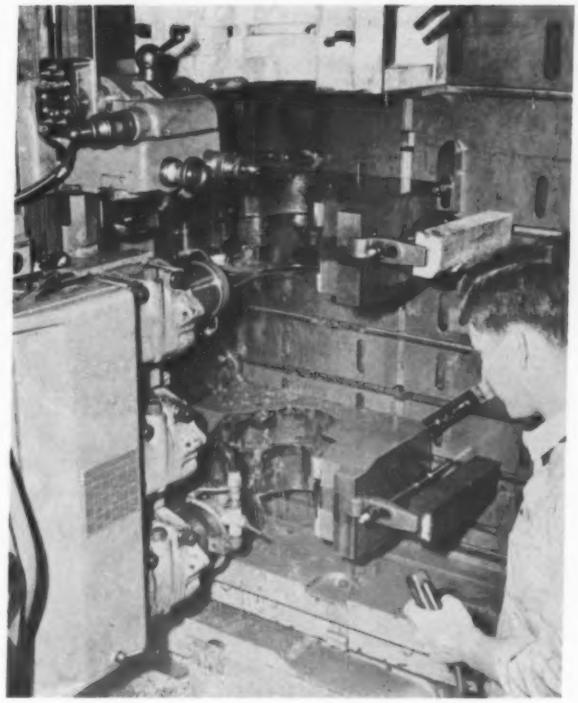
The major factors required to solve this dilemma lie in better pattern engineering and automatic duplicating machines. Machines that will remove metal at a much faster rate than before while reproducing from a model to close tolerances must be used. This rapid metal removal rate is possible because of rigid machine construction and a flood of coolant to the cutting tools. By keeping the cutting tools cool and free from chips they will stay sharp, perhaps ten times as long, as when running at slower speeds on conventional machines without coolant.

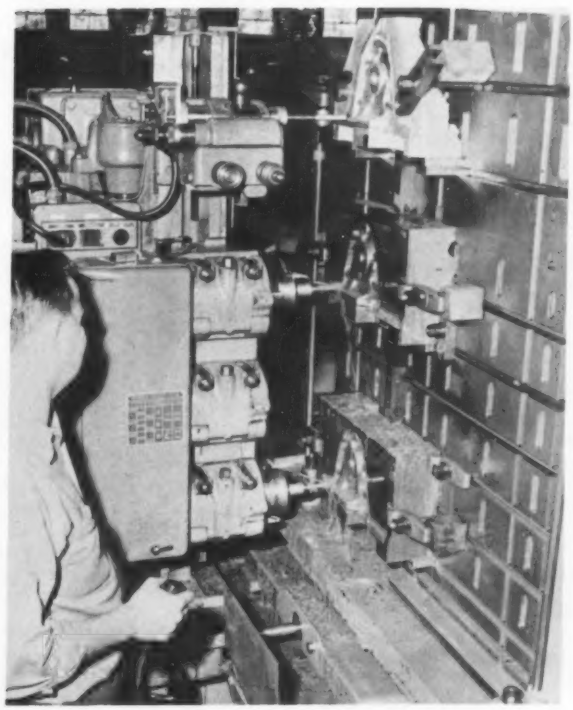
The use of coolant has been more or less restricted in conventional machining because of the necessity to follow layout lines or to watch matching surfaces. To further take advantage of this duplicating equipment, two or more spindles can be used simultaneously. Multiple patterns or core boxes can be cut at one setting of the machine. With some small additional setup time, several pieces can be produced for the price of one.

MACHINES ALONE ARE NOT THE ANSWER

Obviously, this description pertains to milling operations, which constitute the largest volume of machining in most pattern shops. Tracer controlled lathes make repetitive, contour type turning a simple operation. Experience has shown that when four or more pieces are required, a precision template can be made, and the tracing attachment set up with definite savings. In some cases, due to special contours, when only one piece is required, it can be traced.

To make machined patterns competitive through the use of duplicating equipment, the important factors, machine operation and models, must be considered. The first and more obvious concerns the machine operation directly. In comparison with con-





Figs. 2a, 2b, 2c and 2d — A set of hard plaster duplicating models are made from a plaster master core for a three part core box, and two duplicate core boxes are machined at a time for each section.

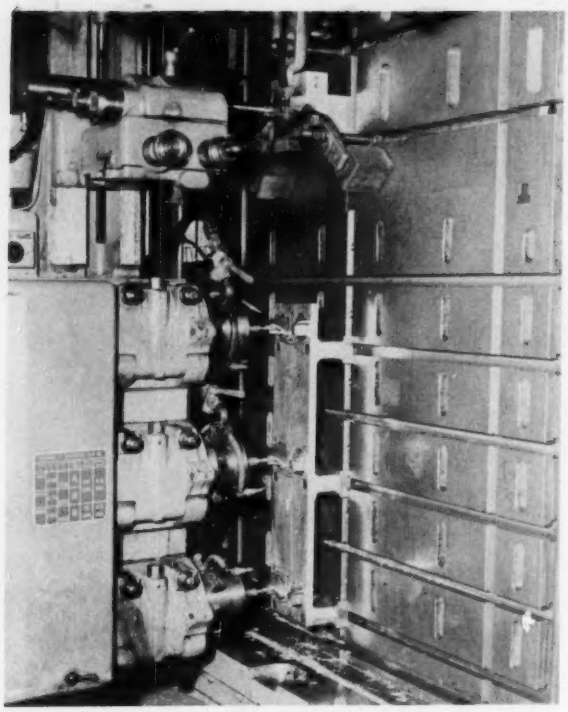


Fig. 3a — One pattern was machined from solid bar stock and test run in the foundry. This pattern (both cope and drag halves) is set up in the top fixture, and three cope and drag patterns are duplicated below.

ventional milling machine operation, cutter size and shape control is an absolute necessity. A minumum of one extra cutter of each specific taper and radius more than the number of duplicating spindles is required. Remember, in multiple spindle duplication the cutters must be identical. Every variation of cutter diameter or radius will be reflected in the machined pattern.

Stylus or tracer points must be made for every different milling cutter used on the duplicator. In most cases four different points are required for each cutter; one for each rough and finish profile, and rough and finish 3-dimensional. These styluses must be cut down or altered, especially those for finishing operations every time milling cutters are sharpened, if known accuracy is to be maintained. Cutters and styluses should be kept in sets and only used for duplicating operations.

It is, of course, fundamental that the duplicator operators be trained in machine potential and operation. They must be supplied with adequate clamps, parallels, keys and other equipment to minimize setup time. It is easy to lose many of the benefits of this type of machine if setup time is exhorbitant.

The second basic problem is more apt to be neglected to a degree in many shops. This is the making of the models or masters for duplication. The finished part cannot be more accurate than its model. Models are usually made from hardwood, metal, plastic and hard nonshrinking casting plaster. The need for working with greater accuracy than ever before

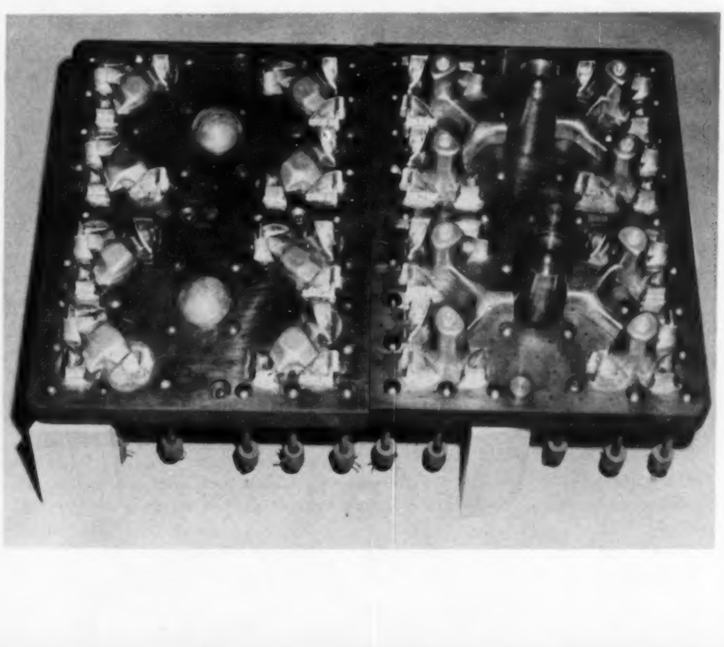


Fig. 3b — Completed pattern plate showing 23 patterns which are duplicated from original pattern, as shown in Fig. 3a.

Fig. 4a — Making a finish cut on two special alloy patterns from a combination hardwood and plaster model.

with these materials is immediately apparent. The use of micrometers, height gages and other precision measuring tools becomes more necessary in wood pattern shops. To get the model made right in the shortest possible time is one of the most important factors in a duplicating setup.

DUPLICATING MASTERS

Before making pattern casting masters, it is sometimes best for the first shop operation to be the making of the duplicating masters. Not all of the dimensional questions come to light in pattern engineering. It is not until the complete object that the engineer is illustrating on the blue print is created that drawing errors or omissions show up. In making the accurate master, at the first step some questions are resolved that otherwise do not come up until the pattern is in the finishing stages of metal work. In case of an engineering error, this sometimes causes costly rework and lost time. Now these questions can be resolved early in the job before much harm can be done.

Duplicating models can be made of one material or a combination of materials as may be practical. For example, assume that both pattern and core box models are to be made for a casting with an irregular contoured wall of uniform metal thickness. All or part of a dummy or core plug would be cut from hardwood to the exact contour of the inside of the casting, allowing only the final casting shrinkage.

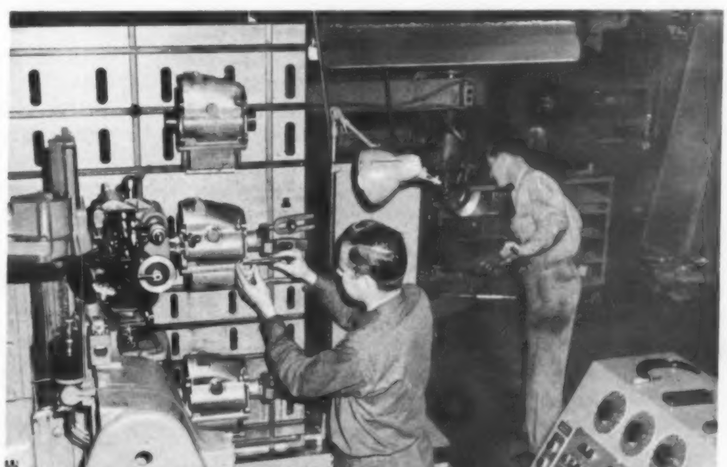


Fig. 4b — Checking duplication accuracy before removing setup from machine saves costly rework.

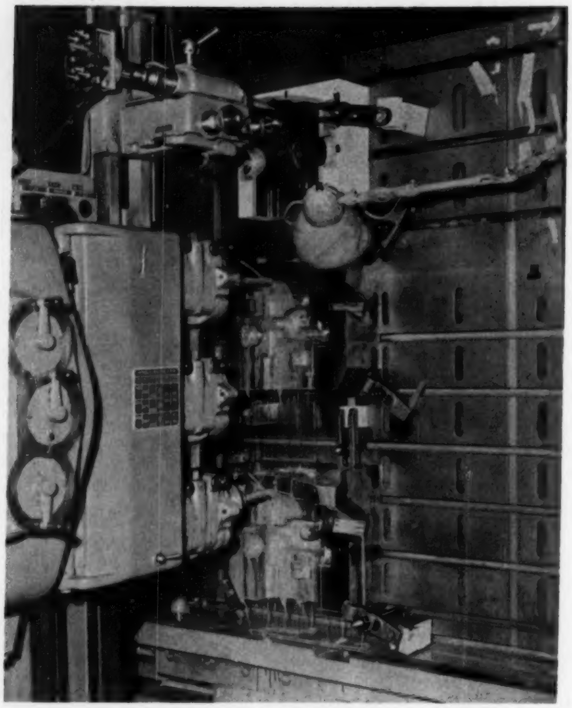


Fig. 4c — By using a hard plaster core box model two impressions of a shell core box are cut to match.

Making a hard, stable casting plaster from this plug will provide a model for duplicating any number of metal core box cavities. With extreme care, this hardwood can be built up with sheet wax or other material to the required metal thickness of the casting. From this a plaster female cast is made. In turn from this female cast, a hard plaster or plastic pattern model for duplicating any number of metal patterns will be made.

During these initial operations, the pattern casting masters can be made through the use of these same materials. Sufficient sheet wax is used to allow for approximately $\frac{1}{8}$-in. pattern machining finish, and for the one additional shrinkage required. By using wood reinforcement, mounted patterns, cover core practice and the like, it is possible to get the required pattern castings without master breakage. Duplicating masters should be checked by the Layout department before proceeding with the steps just described for producing casting masters.

Note that the necessity for detailed involvement in the pattern configuration occurs once in the wood shop and once in the metal shop, early in the stages of making the pattern. In the old step-by-step machining practice it is necessary for this involvement, or concentration, to be carried by the metal Layout department all through the making of the equipment. A serious loss of time by critical manpower.

SMALL PATTERNS

In the case of smaller patterns, it is often more practical to proceed in the old way up through the rough machining operations (heights, etc.) with no duplicating master prepared.

One of these smaller patterns can be machined and benched in conventional operations and used for a duplicating master after checking. Automatic multiple spindle duplicating can eliminate the need for many small master patterns. A stock of material can be kept on hand; cast, rolled or forged, from which metal patterns can be cut from the solid. Pattern deliveries can be shortened by eliminating the master and pattern casting operations.

By taking advantage of the faster stock removal in the duplicating machine, no hardship is created. By using more rolled or forged raw material for smaller patterns and core boxes, the porosity problem of pattern castings is eliminated. This is particularly important with shell molding patterns and core boxes.

Many shops have spent considerable time and effort attempting to make cast to size pattern equipment good enough for their customers. Even though master patterns are right on the button, some casting variation usually occurs, regardless of which precision casting technique is used. It is natural for metal solidifying in a mold to distort to some extent. It is common practice to machine core prints and other critical areas of precision pattern and core box castings. To properly locate these areas on a precision casting requires considerable care in the metal Layout department. In many cases it is necessary to repair or patch where distortion takes place, or surface finish is not satisfactory for bench cleanup. By using the same care on master work, coupled with duplicating practice, it is possible to get a much better job done at a comparable cost.

Many production foundries have found that excessive wear and breakage have dulled the glamour of low cost plastic patterns. While you cannot duplicate an all machined metal pattern for anything like the cost of a plastic pattern, it will outlast the plastic pattern many times. The critical problem here is foundry down-time, which in the case of a broken plastic pattern, can be extremely costly.

If sufficient perseverence can be extended along the lines just covered, the results can be amazing. Rome was not built in a day. To give modern foundries the best tool at the lowest cost in the least time, machined patterns can be competitive.

NEW PROCESS FOR FOUNDRY IRON

by T. E. Ban, B. W. Worthington and C. D. Thompson

ABSTRACT

A description of the D-LM Process for making iron is presented. The process makes use of low rank raw materials, conventional metallurgical equipment and techniques of pelletizing, carbonizing and smelting. A review of the history and circumstances which led one author's company to sponsor initial development of the process is given.

Pilot plant operations using a relatively low grade Lake Superior iron ore are described to illustrate the functions and technology of the various process phases. The data and results of this operation show the requirements of electrical energy, iron ore, noncoking coal, limestone and other raw materials for producing foundry grade iron. The simple and rapid method of process control for maintaining the desired iron and slag compositions is described and illustrated with diagrams. Considerations of the requirements for various capacities of commercial size plants are discussed.

INTRODUCTION

Colonial iron making began in America as early as 1645 with the establishment of successful iron works in the Massachusetts Bay settlements. Bog and rock ores were smelted in the early blast furnaces with charcoal. Excellent grades of iron were produced and used for casting items such as pots, firebacks, scale weights and "sow" bars. The latter were forged and used for making bars, rods and flats. From this beginning, the American blast furnace has evolved into a giant that is nine stories high and produces nearly 3000 tons of iron per day. To attain high productivity and efficiency modern blast furnace technology makes use of humidified blast, fuel injections, oxygen enrichment, high top pressures and beneficiated burdens.

During the last decade beneficiated burdens, comprised of sized ore, sinter, pellets or self fluxing sinter, have been used as a means of increasing blast furnace capacities and decreasing coke requirements. Self fluxing sinter is presently being widely used because it contains the fluxes in a reacted form and possesses beneficial thermal, physical and chemical properties. A research endeavor to beneficiate burdens "beyond" self fluxing sinter led to the development of the D-LM Process, a multi-stage method of making iron.

PROCESS DESCRIPTION

Figure 1 presents, in simplified form, flowsheets for the modern blast furnace process and for the D-LM Process. The drawing shows iron ore and limestone formed into self fluxing sinter in a sintering plant, and the coal formed into coke in a by-product coke plant. These materials are charged as layers in the blast furnace where coke reacts with large quantities of air for heating and reducing the charge. Coke also serves as a thermally stable medium for supporting the burden within the furnace. The charge materials are resident in the furnace for periods of 8 to 14 hr, and the liquid products of iron and slag are intermittently tapped.

The blast furnace flowsheet, with the attendant sinter and coke plants, illustrates the practice of altering raw materials to conform to requirements of metallurgical equipment. The D-LM flowsheet in Fig. 1 shows the basic steps of the process in a comparative manner with the blast furnace, and illustrates metallurgical equipment and techniques arranged to conform to the characteristics of raw materials. The techniques shown are raw materials preparation, balling, carbonizing and reduction and finally smelting. Raw materials, consisting of iron ore fines, noncoking coal fines and limestone fines, are proportioned to obtain the desired metallurgical grades of iron and slag.

Preparation of the proportioned ingredients is made to obtain a suitable physical texture for balling and a homogeneous mixture for processing. Preparation may range from a simple mixing circuit, if the raw materials are comprised of concentrates and powdered fines, to a more complex grinding circuit comprised of grinding mills with attendant dewatering equipment. Normally the extent of preparation is controlled to obtain a raw materials structure of minus 20 mesh.

The prepared raw materials are formed into balls or green pellets that are about ½-in. in diameter. These can be prepared in a balling drum or a balling disc. The balls are fed in an even, shallow layer on a sintering machine where they become sequentially dried, ignited and carbonized as they are moved horizontally across the machine in a quiescent state.

T. E. BAN is Vice-Pres., Rsch. and C. D. THOMPSON is Asst. to Dir. of Rsch., McDowell Co., Inc., Cleveland and B. W. WORTHINGTON is Dir. of Rsch., McWane Cast Iron Pipe Co., Birmingham, Ala.

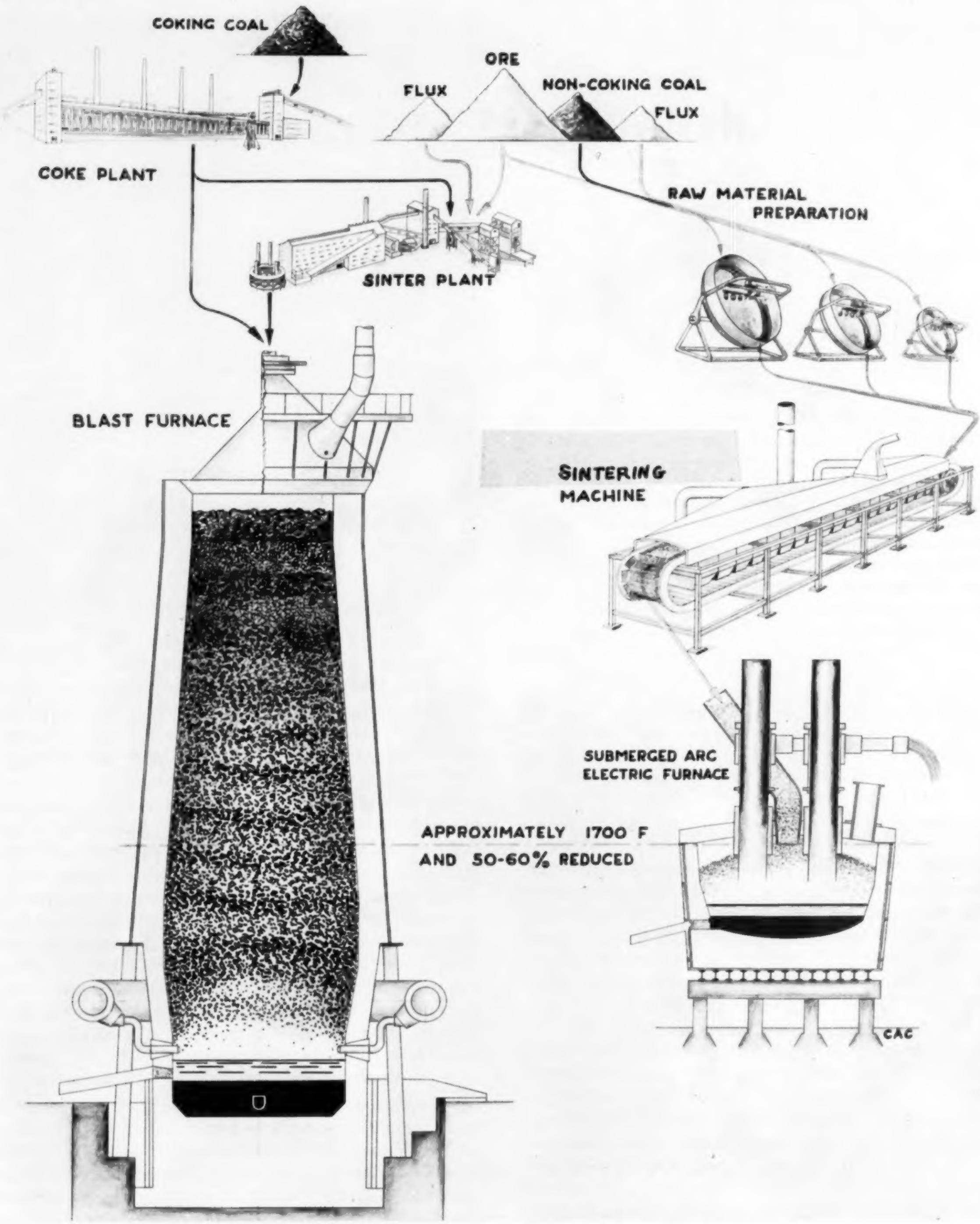


Fig. 1 — Typical modern blast furnace and D-LM processes flowsheets.

Drying is accomplished by recirculating hot gases from the carbonizing zone, and this serves to remove moisture and preheat the balls. Control of the hot gases is used to avoid spalling and preignition during drying.

Carbonizing Treatment

The charge is ignited with a stationary torch that serves to initiate the bed reactions in the carbonizing zone. In this zone several important phenomena take place, converting the balls into carbonized pellets. These are:

1. Complex reactions, pyrolytically processing coal into a coke-like structure as a hard char, take place. This serves to bond the ingredients in the pellets and to provide carbon for subsequent reduction and carburization in the electric furnace. The char

bond provides a thermally stable structure similar to the coke matrix of the blast furnace.

2. Combustion reactions within the pellets and pellet bed during carbonizing provide heat and reducing gases. These cause pellets to attain a temperature of about 2000 F (1090 C).
3. The oxides of the ore are reduced to lower oxide levels and some iron is reduced to the metallic state. During carbonizing approximately 50 to 60 per cent of the oxygen is removed from the oxides of the ore.
4. The calcium and magnesium carbonates of the flux are decomposed to an extent that the flux is more than 75 per cent calcined.

The product from the sintering machine is a preheated, self fluxing, self reducing pellet charge that is both chemically and physically beneficiated.

The 1700 F (930 C) line of Fig. 1 illustrates a common extent of processing for both the blast furnace and the D-LM processes. This is acquired by distinctly different metallurgical techniques. In the D-LM Process fine intimate ingredients are composited into pellets and reacted on a sintering machine. In the blast furnace process coarse and individual raw materials from a coke plant and a sinter plant are processed in the shaft portion of the furnace. At the 1700 F (930 C) line, the expired processing time of the two techniques of making iron is significantly different.

Approximately 15 to 20 min have been required in the D-LM Process to produce the carbonized pellets, while 4 to 5 hr have been required in the blast furnace to process the raw materials to a similar thermal and chemical state.

In the D-LM Process a conventional submerged arc electric furnace is used for completing the high temperature hearth reactions which produce the liquid iron and slag. This type of furnace is currently used in several European and Latin American countries for producing pig iron, and it is similar to electric furnaces used in North America for making ferro-alloys, calcium carbide and phosphorous. The furnace is particularly adaptable for final smelting in the D-LM Process because the short stock column does not require high strength burden materials, the high temperature crucible formed from the buried arc system gives rise to rapid smelting rates and minimum quantities of gases pass through the burden column. Because of charge reactivity, considerable indirect reduction takes place to give a CO to CO_2 ratio of about 1.6.

Raw materials of this new process are proportioned and controlled to produce target grades of iron and slag. These are usually foundry or basic grades of pig iron, although silvery pig iron and white pig iron can be made with facility. Slags are normally designed for unit basicity, but this can be altered in accordance with the desired metallurgy.

PROCESS DEVELOPMENT

One author's company is a manufacturer of centrifugally cast water and gas pipe and, as such, is a large consumer of pig iron. During national emergencies, or when there was a shortage of pig iron, it became necessary to curtail or even discontinue operations because of a lack of this essential raw material. After a study of market conditions and plant operations in this country and in Europe, it became evident that in a highly competitive industry under severe economic conditions, those cast iron pipe companies which produced their own pig iron would possess an economic advantage. It became advisable to investigate ways and means of producing iron.

Iron Production Methods

During 1948 a study was made of various known methods of producing iron. The blast furnace, acknowledged for centuries as the most economic means of producing pig iron, did not appear attractive at this time, because it was only economical when furnace capacity was in the range of 1200 to 1500 tons per day. With two widely separated pipe making plants two furnaces would be required, and the capital investment would be in the range of $50,000,000 to $80,000,000. Furthermore, such a solution would necessitate getting into the merchant pig iron business, since there would be produced 1600 tons of iron per day in excess of the requirements. Also, it was believed unlikely that the blast furnace metal could be used directly for casting.[1]

From many standpoints—unit size, compactness and low investment cost—electric furnace smelting, as represented by many successful pig iron furnaces in Europe, was of interest. However, normal electric furnace operation can compete with the blast furnace only under a specific set of conditions, namely, when cost of electricity is extremely low and when insufficient metallurgical coking coals are available. Generally, these conditions do not prevail in many industrial areas of the United States.

In view of these considerations, it was decided to discuss the problem with Battelle Memorial Institute. Before offering any specific approach to the research problem, it was proposed to first make a fundamental study of the various phases of the blast furnace process, namely, 1) preheating, 2) reduction and 3) smelting. This was initiated to determine the reactions rates that governed residence time in the blast furnace, and to indicate the type of equipment which would accomplish these functions in the shortest possible time.

These general conclusions were made:

1. A tendency for a marked increase in reaction rates between intimate mixtures of finely divided materials was confirmed. Mixtures of finely ground ore and coal were almost completely reduced in 15 min at 2000 F (1090 C).
2. The sintering machine was found to be the most effective means of preheating and prereducing large tonnages of bulk materials. With this mechanism a furnace charge could be preheated to 1600 F (870 C) in a matter of 15 min or less, whereas several hours might be required by other conventional apparatus.
3. Under proper conditions at 3000 F (1650 C) all of the normal hearth reactions of the blast furnace could be completed within one hr.

4. When pelletized mixtures of 60 parts of fine ore and 40 parts of fine coal were reacted, the product obtained was 30 per cent completely reduced and had considerable physical strength. Although some reduction was anticipated, the amount of reduction, strength of product and residual carbon retained in the sintered product were unexpected.

In view of these conclusions, it was believed that if proper conditions were maintained and satisfactory equipment was used for separating the various functions of the blast furnace, the time requirements of smelting could be decreased markedly and hence smaller tonnage operations might be economical.

Pilot Plant Flowsheet Circuit

Research was continued with an extensive series of bench scale tests and the results showed optimum conditions for attaining the most desirable pellet properties on the sintering machine. This work justified establishing a small pilot plant flowsheet circuit using a patented sintering machine and a short shaft blast furnace. The results of these pilot plant experiments were successful with regard to the application of the sintering machine for prereduction and preheating, but it was learned that the short shaft blast furnace had shortcomings.

Economic projection of this type furnace indicated that it would be necessary to equip it with many auxiliaries required for a regular blast furnace. This evaluation also showed that if prereduced pellets were available, an electric furnace installation would be more economical from the standpoints of both capital and production costs.

Because of early assistance and association with the project, one author's company sponsored permanent pilot plant facilities to administrate commercialization of the process. To acomplish this, a newer and larger pilot plant was erected in Cleveland to treat a wide variety of raw materials for establishing bases for economic evalutions and engineering designs.

PILOT PLANT OPERATIONS

This pilot plant is equipped for processing a wide variety of materials from the natural bulk state to pig iron at a capacity of about 10 tons/day. Operating techniques for treating a group of raw materials can be described by the procedures used with a certain ore, coal and limestone in an evaluation program. As an example, the procedures and techniques used for making a foundry grade of iron from a Mesabi "earthy" type of ore are described. However, it should be emphasized that many different types of iron ores and concentrates and coals have been applied in the pilot plant using various techniques.

A high volatile bituminous, 1¼ by 0 in. Ohio coal was used as a reductant, and initially it was dried and ground to minus 20 mesh. A powdered Ohio limestone was used as the flux. The dried coal and limestone powders were stored in bins for feeding the circuit. The minus ½-in. Mesabi Ore and 80 per cent of the required amounts of coal and limestone were fed from individual feeders in accordance with burden designs for making a foundry grade iron containing 3.5 per cent C, 2 per cent Si and a slag with a basicity ratio of 1.3. The raw materials were conveyed to a hammer mill equipped with ¼-in. grate bar apertures.

The hammer milling action thoroughly mixed the ingredients and reduced the coarse portions of the ore to minus ¼-in. Use of powdered limestone and coal reduced the overall moisture content of the mixture, and eliminated problems of sticking and clogging in the mill normally encountered with this type of ore. In this case the dry grinding and hammer milling represented the raw materials preparation required for processing.

The hammer milled mixture was stored in a large bin and was fed by a table feeder into a pug mill. Final additions of powdered limestone and coal were added to the mixture in the pug mill. The control of the additions was determined by analyses of the iron and slag.

Balling Disc and Sintering Machine

The pug mill discharge was conveyed to the 7½-ft diameter balling disc where it was formed into ½- by ⅜-in. balls. These were fed to the 2 by 16 ft sintering machine where they were dried, ignited and carbonized. The balling and carbonizing apparatus are shown in Fig. 2. The machine discharge, consisting of hot reduced pellets, was collected in a bin and fed to a screen where minus ⅛-in. fragments and fines were removed. Sized material was discharged into a skip and raised to a furnace feed hopper, and fines were recirculated and fed in controlled amounts with the powdered limestone and coal into the pug mill.

The furnace was choke fed from the hopper through a single feed pipe located within the center of the furnace electrode delta. Figure 3 shows the electric furnace with the charging equipment. With the method of charging, the furnace was continually filled and buried electrode arcs were maintained during smelting. Electricity for smelting was supplied through three 10 in. electrodes that were connected to a 500 kva transformer. Electrical conditions were controlled by adjusting furnace voltage and electrode levels to obtain the desired furnace temperatures. Normally the product was tapped at about 2800 F (1540 C).

Pig iron and slag were tapped from a single tap hole and were collected in a series of 24 in. ladles. Slag was skimmed from the ladles, and the iron was cast in pig molds arranged in a cascading fashion. Approximately twenty 90 lb pigs were obtained from each cast. Samples of the iron and slag were taken for chemical analyses, and a standard A.S.T.M. type C-3 chill block sample was poured to obtain a visual indication of the carbon and silicon contents of the iron.

PILOT PLANT TEST RESULTS

The operation previously described was used for a pilot plant test to evaluate a relatively poor quality Mesabi ore, a high sulfur noncoking coal and a low grade limestone. These were selected for evaluating inferior grades of raw materials in this new process.

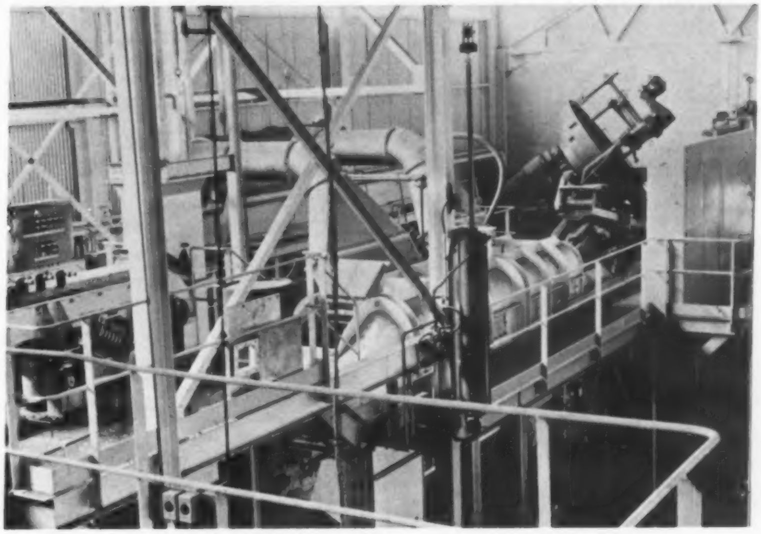


Fig. 2 — Interior view of pilot plant showing balling and carbonizing apparatus.

Analyses of these raw materials are given in Table 1. The target grade of metal for this evaluation was a foundry grade of iron containing 3.25 to 3.5 per cent C, 2.0 to 2.25 per cent Si and 0.05 per cent S. This grade was selected because it approximates the composition of Class 30 cast iron.

After completion of the pilot plant test, the operating data, samples, analyses and product weights are compiled. The results of this compilation are used to make a materials flow diagram that designates the quantities of raw materials required to produce one net ton of product. These data and the operating data serve as a basis for the evaluation of a plant.

The results of this pilot plant test are shown in the materials flowsheet of Fig. 4, and analyses of the products are presented in Table 1. The flowsheet shows the principal raw materials required for producing one ton of foundry iron in the pilot plant flowsheet to include 3830 lb of iron ore, 1803 lb of coal, 1326 lb of limestone and 1218 kwh of electrical energy.

This pilot plant evaluation illustrates the use of low rank, low cost raw materials and operating conditions with high slag volumes and relatively high electrical energy requirements. The high slag volume was beneficial for attaining a low sulfur iron with the use of the high sulfur coal as a reductant. The electricity requirement of 1218 kwh/net ton of pig iron, shown in Fig. 4, was obtained from a pilot plant furnace operation with an efficiency of about 70 per cent. Translation of these data to a commercial size furnace with an efficiency of about 82 per cent would show a requirement of 1040 kwh/net ton of iron. The basis for this scale up, and the translation of pilot plant results, has been previously shown in detail.[2]

PROCESS CONTROL

Control of the raw material ratios is used as the principal means of process control for maintaining the target grades of iron and slag. Through use of additive feeders, additions of powdered limestone and coal can be controlled to meet a desired metal-

TABLE 1 — ANALYSES OF RAW MATERIALS AND PRODUCTS

Analyses (Natural Basis)	Raw Materials: Iron Ore	Coal	Limestone	Products: Iron	Slag
Moisture, %	10.0	2.5	0.5	—	—
Fe, %	47.6	2.8	0.4	—	0.7
Acids (SiO_2 & Al_2O_3), %	11.5	8.2	5.9	—	42.4
Bases (CaO & MgO), %	1.4	0.2	48.3	—	56.1
LOI, %	7.2	—	42.5	—	—
S, %	0.1	2.5	0.2	0.06	—
VM, %	—	36.6	—	—	—
C, %	—	48.3	—	3.53	—
Si, %	—	—	—	2.02	—
Mn, %	—	—	—	0.72	—
P, %	—	—	—	0.12	—

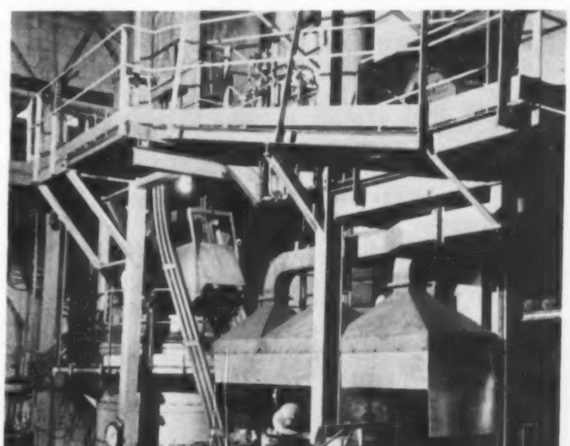


Fig. 3 — Interior of pilot plant showing screen, skip and electric furnace.

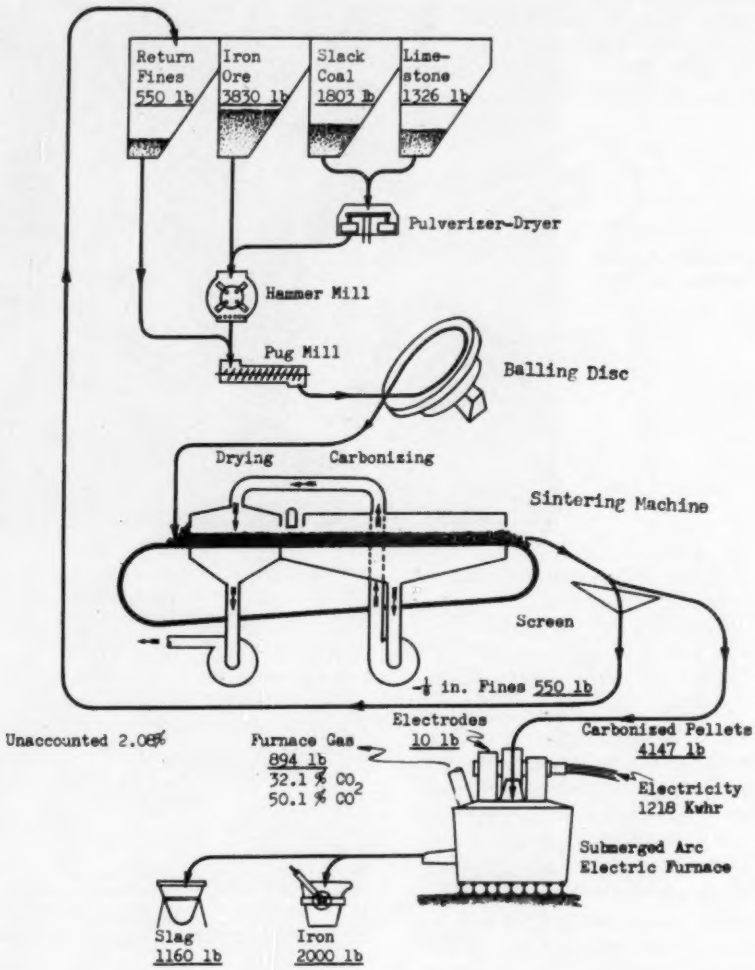


Fig. 4 — Materials flowsheet of pilot plant operation using Mesabi iron ore mixture, Ohio coal and powdered limestone. Basis: Natural raw materials for one net ton of iron.

lurgical change. Within 15 min following such a change, the composition of the carbonized pellets or electric furnace feed alters in accordance with the charge. This method of control is illustrated in Fig. 5, which shows changes in the coal to ore ratio to be followed within 15 min by changes in the per cent of carbon in the carbonized pellets.

The FeO in the slag reflects the changes of carbon in the system and lags the change of the coal to ore ratio by about 1½-hr. Similar control is shown by the changes of the limestone to ore ratio and the resulting basicity of the slag. Figure 5 illustrates data obtained during a period when experimental control was being examined in the pilot plant.

Control of the pellet composition can also be attained by altering the retention time and draft rate of carbonizing. However, this form of control is used less frequently because it disturbs optimum operating conditions. Control of the temperature within the furnace, and to a limited degree the composition of the products, is obtained by altering the electrical operating conditions of the furnace.

COMMERCIAL PLANT CONSIDERATIONS

Many varieties of ores, coals and fluxes have been tested in this pilot plant. The purpose of the tests is to establish raw material requirements, to acquire basic engineering design and to obtain necessary data for economic evaluations of raw materials in this process. There are many technical reasons for this evaluation. The raw material preparation for each type of ore differs and may include crushing, dry grinding, wet grinding or simple blending. The burning and carbonization characteristics of each coal differ and will require research for determining the proper operating conditions to obtain optimum pellet strength and reduction. It is also important to obtain data of the operating conditions for the electric furnace with regard to each group of raw materials and the desired analysis of iron.

Translation of the pilot plant data into economic considerations requires a thorough evaluation of the developed flowsheet along with the engineering layout. The flowsheet determines raw material, energy and equipment requirements. The engineering lay-

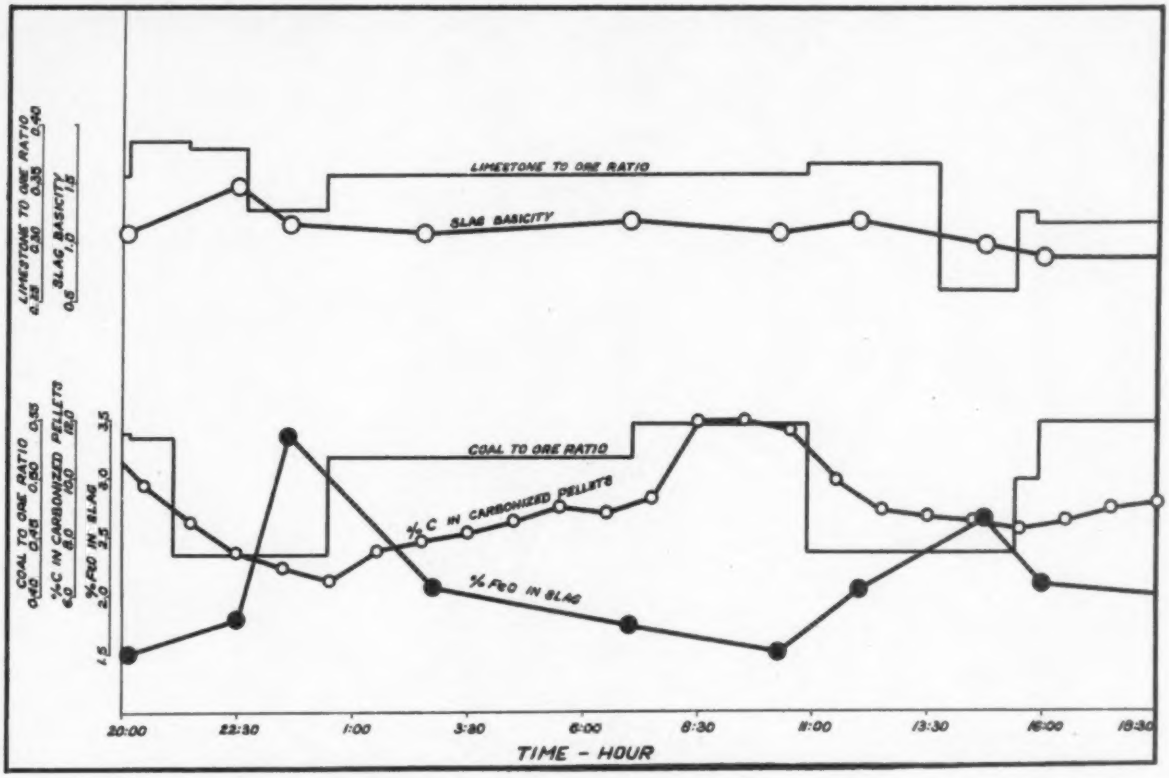


Fig. 5 — History of metallurgical effects from burden alterations.

out designates labor or manpower requirements and capital charges.

Raw material requirements and costs will depend on the grade of the material. Transportation costs will also influence raw materials costs at the proposed plant. Examples of economic evaluations using relatively high grade raw materials in this process were presented in a recent publication.[3] This showed the costs of iron ore and electricity to vary considerably with location of the plant site. The examples illustrated raw materials costs to change pig iron production costs about $10 when there is a variation of ore costs of $3, coal costs of $2 and electricity costs of 4 mils.

Relatively poor grade raw materials were used in the previously described pilot plant tests. The Mesabi iron ore contained 47.6 per cent Fe (natural basis), the coal was a noncoking coal containing 2.5 per cent S and the limestone contained 5 per cent acid insolubles. Even though these low grade raw materials may be obtained at a low unit costs, the advantages may be offset by the greater energy requirements for producing iron with high slag volumes. An estimated cost of these raw materials in a Great Lakes Area would be about $36, as presented in Table 2. These can be contrasted to higher grade raw materials in the St. Lawrence River Area, also given in Table 2. These costs include iron ore, coal, flux, electrodes, water and total electricity.

Production cost considerations for different size plants for this process include the raw material costs and operating costs which will vary with the size or capacity of the plant. Figure 6 illustrates operating costs as a function of the daily capacity of different size plants. As the tonnage decreases from 550 to 100 net tons/day, the operating costs, based on 336 days/year operation, increase from $9.85 to $23.52. This increase is attributed to increased manhour requirements and increased fixed costs including interest, amortization, insurance, etc.

From these data and the data of Table 2, it can be seen that in an area with a favorable raw material situation such as the St. Lawrence River area, total production costs for a net ton of foundry iron can range from $38 for a 550 net ton/day plant to

TABLE 2 — ESTIMATED RAW MATERIAL COSTS

	Lake Erie Area Mesabi Ore			St. Lawrence River Area Canadian Concentrate		
Raw Material	Quantities	Unit Cost	$/NTPI	Quantities	Unit Cost	$/NTPI*
Iron Ore	1.71 GT @	$10.61	$18.14	1.52 GT @	$9.50	$14.44
Noncoking Coal	0.90 NT @	6.34	5.71	0.84 NT @	9.00	7.56
Limestone Fines	0.66 NT @	3.08	2.03	0.20 NT @	2.50	0.50
Electricity						
Smelting	1040 kwh			890 kwh		
Auxiliary	60 kwh @	0.008	8.80	60 kwh @	0.004	3.80
Electrodes	10 lb @	0.14	1.40	8.2 lb @	0.14	1.15
Water	9000 gal @	0.03/1000	0.27	9000 gal @	0.03/1000	0.27
			$36.35			$27.72

*Dollars per net ton of pig iron.

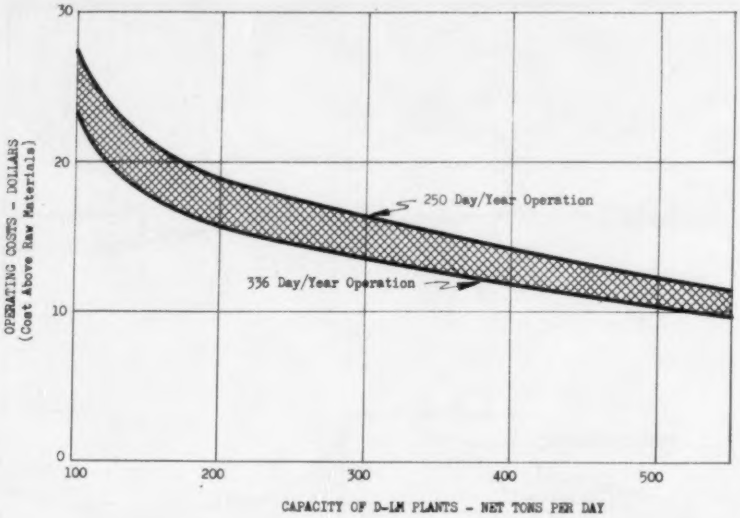


Fig. 6 — Operating costs as a function of capacities.

$51 for a 100 net ton/day plant based on 336 days/year operations. In an area with a slightly less favorable raw material situation such as the Lake Erie area, the total production costs for a net ton of foundry iron can range from $46 for a 550 net ton/day plant to $59 for a 100 net ton/day plant. These cost ranges compare favorably with the estimated cost of $58.40 for hot metal in a possible average foundry.[4]

If fewer operating days per year are to be considered, the operating costs will be increased from $2 to $4/ton depending on the size of plant. These costs are illustrated as the upper line in Fig. 6, and are based on operations at 250 days/year (five day week).

SUMMARY

The D-LM Process is a novel method of making iron using low rank raw materials and conventional metallurgical equipment. Iron ore, noncoking coal and limestone are prepared and blended in the metallurgical proportions required for making pig iron and slag. Blended fine materials are formed into balls about ½-in. in diameter and are placed on a sintering machine where they are sequentially dried, ignited and carbonized. During carbonization, the coal forms a coke-like matrix which bonds the pellets, the iron ore is reduced to an extent where more than 50 per cent of the oxygen is removed from the ore and the limestone is partially calcined. The hot, self-fluxing, prereduced pellets are charged to a submerged arc electric furnace where final smelting takes place, and liquid iron and slag are formed. Liquid products are tapped intermittently and the iron can be pigged or used as hot metal.

The operating procedures for evaluating a relatively poor grade Mesabi Ore and a high sulfur coal in a pilot plant included preparing the raw materials by dry grinding the coal and hammer milling a mixture of iron ore, coal and powdered limestone. This mixture was then balled, carbonized and smelted in the laboratory flowsheet circuit. The data from the continuous test were carefully evaluated and showed that the 500 kva pilot plant furnace required 1218 kwh/net ton of pig iron containing 3.53 per cent C and 2.02 per cent Si. Based on previous experience this electricity requirement can be scaled to 1040 kwh for a commercial size furnace with an 82 per cent efficiency.

Principal process control is maintained by changing the proportioned ratios of ingredients. The new ratio is shown to effect the composition of the furnace feed within approximately 15 min following the change. The composition of the carbonized pellets can also be controlled by draft conditions on the sintering machine.

Considerations for various size commercial iron plants for this process are shown in the operating costs of plants decreasing in capacity from 550 to 100 net tons/day. The operating costs range from about $10 to $23/net ton of foundry grade iron. Total production costs will depend on the sum of the operating costs and raw material costs, and can range from about $38/net ton of iron to about $59/ton of iron depending on the plant capacity and on the grade and source of raw materials.

ACKNOWLEDGMENT

The writers express appreciation to three organizations for their contributions to this development. In this respect the contributions by McWane Cast Iron Pipe Co., McDowell Co., Inc. and Battelle Memorial Institute are acknowledged. Special efforts for this presentation by Messrs. D. C. Violetta, C. A. Czako and C. J. Nelson are appreciated.

REFERENCES

1. P. Dwyer, "Superheats Direct Metal Electrically for Automobile Castings," *The Foundry, vol. 55*, no. 18, p. 710 (Sept. 15, 1927).
2. T. E. Ban and B. W. Worthington, "Technology of Dwight-Lloyd McWane Ironmaking," *Journal of Metals, vol. 12*, no. 12, p. 937 (Dec. 1960).
3. R. C. McDowall, "Iron Making by the Dwight-Lloyd McWane Process," *Mining Congress Journal, vol 46*, no. 10, p. 58 (Oct. 1960).
4. H. W. Lownie, Jr. and A. J. Stone, "Foundries Can Produce Their Own Cast Iron Directly From Ore," AFS TRANSACTIONS, *vol. 67*, p. 1 (1959).

BRONZE ALLOYS ELECTRIC MELTING AND QUALITY CONTROL

by R. V. Barone, T. F. Godfrey and R. A. Rosenberg

ABSTRACT

A general discussion is presented of low frequency induction melting including melt covers and theory of operation. A method of quality control was devised and employed in the authors' company's bronze foundry to maintain stricter control over melt analyses. The zinc losses of A.S.T.M. B62 (85-5-5-5) were found to be 0.8 per cent during melting and procedures were then developed to replace these losses. The change in zinc content (from 4.8 per cent to 5.5 per cent) produced an increase in the average yield from 16,250 psi to 16,750 psi, while exhibiting little correlation of the tensile strengths and elongations obtained from approximately 70 production tests per month. This resulted in economic savings of over $700 per month on raw materials, and in improved consistency in alloy foundry properties and mechanical properties.

X-ray fluorescence was employed to monitor the zinc content of the 85-5-5-5 alloy over a period of 4 months, in addition to approximately 70 wet chemical analyses made per month over the entire 10 month testing period. The use of x-ray fluorescence is discussed and its advantages as an accurate, rapid means of analysis is cited.

INTRODUCTION

The bronze foundryman has always desired maximum yield from both his equipment and his time. In order to fulfill this wish and to obtain and maintain an operation at peak efficiency, a system of quality control which includes systematic reviews of all foundry operations is essential.

Quality control, beginning with the initial charge segregation, must be maintained until the completed casting leaves the foundry. It is of extreme importance to check on the condition of a casting in various stages of its production, for if a casting is made poorly in the foundry it becomes both useless and wasteful to perform any subsequent operations on it.

In melting bronze, it is imperative that deleterious impurities be minimized. Major impurities to be guarded against in melting tin bronzes and red brasses fall into two categories. The first includes metals such as iron, antimony, silicon and aluminum which alter the foundry properties. Next, are the nonmetallics such as sulfur, sand, slag and gases including carbon monoxide, carbon dioxide, water vapor and sulfur dioxide.

R. V. BARONE is Rsch. Met., Rsch. and Engrg. Div., T. F. GODFREY is Fdy. Supt., Braintree Works and R. A. ROSENBERG is Chief Matls. Engr., Rsch. and Engrg. Div., Walworth Co., South Braintree, Mass.

These impurities may enter the melt either in the charge or from contact of other materials with the molten alloy. The former may be adequately controlled by proper segregation and cleaning of the charge, thus minimizing both mixed metal and gangue forming materials. The later source includes all substances which contact the molten metal. Furnace linings, ladle linings, skimmers, molds, slags, covers and the atmosphere fall into this category and all should be as clean and dry as possible.

The purpose of this work was to devise a procedure for the close control of metal chemistry. This was felt to be important since if metal chemistry varies extensively, 1) the resulting alloy may fall out of chemical specifications limits, 2) metal costs may be excessive since low cost alloy constituents may not be maximized, 3) the mechanical properties may not meet specifications and 4) the foundry properties (e.g, fluidity, shrinkage, etc.) may change thus producing erratic casting results.

LITERATURE REVIEW

Melt Control Impurity

Foreign elements such as silicon and aluminum are known to have detrimental effects on casting properties. Colton[1] presents data on red brasses which illustrate that as little as 0.005 per cent of either aluminum or silicon will cause a reduction in both tensile strengths and per cent elongation, while 0.20 per cent aluminum, 0.02 per cent manganese or 0.10 per cent magnesium will cause the shrinkage formation to change from a randomly dispersed interdendritic type to a gross localized type.

St. John[2] points out that for alloys such as red brass and tin bronze, even a change in metal chemistry within specification limitations may alter the optimum pouring range considerably. For example, a variation of the iron content from 0.05 to 0.25 per cent may cause a 50 F difference in pouring temperature. Variations in nickel content may also produce considerable change. Ames[3,4] has shown that the pouring temperature affects the solidification characteristics of tin bronzes, and that under production conditions it can have a profound effect on pressure tightness, tensile strength, ductility and density.

Its effect on the physical properties of A.S.T.M. B62 (85-5-5-5) has been substantiated by the A.S.T.M.

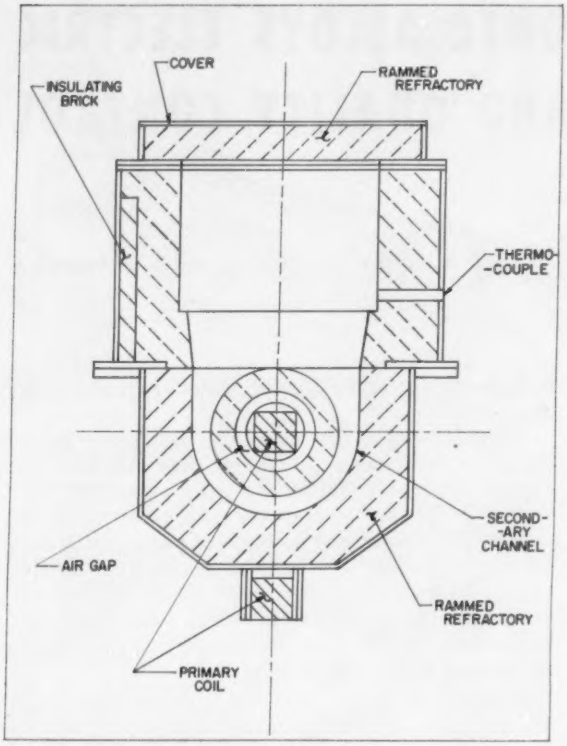


Fig. 1 — Schematic cross sectional view of one at the low frequency induction furnaces.

production tests[5] performed at the authors' company. Due to this, a pouring range for not only the cast tensile bars but also each individual casting made in the company is specified.

Unfortunately, the literature on the removal of impurities is limited. However, there are several articles which discuss the production of copper and copper-base alloys which may be helpful if impurity reduction is necessary.[6,7,8,9,10,11]

Melt Covers

Basically, there are five types of covers which can be used in the refining process—acid, basic, neutral, oxidizing and inert. Silica is the most common acid flux which will react with basic or amphoteric substances and produce a silicate slag. The basic fluxes include lime (CaO), either hematite or magnetite, soda ash or sodium carbonate. These react with the acidic substances. Borax ($Na_2B_4O_7$) and fluorspar (CaF_2) are two common neutral fluxes employed where there is either little slag forming material, or when it is desirable to reduce the liquidus temperature of the slag to produce a fusible material which will absorb the impurities.

The oxidizing type would include materials such as niter or sodium sulfate which supply oxygen and remove impurities by a process involving oxidation reactions. Another cover used primarily to prevent or decrease metal oxidation is the inert cover which works by reducing the amount of contact between the melt and the atmosphere. These include gases which do not react with bronze such as argon or nitrogen.

Baer, et al,[12] reported their results on the mechanical properties of the valve bronze melted, 1) in air, 2) under dry charcoal and 3) under damp charcoal, which showed that the first produces favorable mechanical properties, the second is much less favorable and the third method results in extremely poor properties. With the low frequency induction furnaces at the authors' company, a graphite flake cover, if used prior to 8 hr shut down in the evening, helps to prevent a hard crust buildup of material in the furnaces without noticeably affecting the mechanical properties of the material. The latter was determined by comparing the tensile data of heats poured early in the day with those for heats poured later.

EXPERIMENTAL PROCEDURE

Melting Apparatus

Melting was carried out in low frequency induction furnaces using commercial B-62 ingot. Chemistry and physical properties of the alloy are listed in Table 1. A schematic diagram of one of the two furnaces used is shown in Fig. 1. The furnace consists essentially of, 1) steel laminations, 2) primary coil, 3) refractory lining and 4) secondary channel with the pool of molten metal. Furnaces employed were 6000 lb capacity, and are well suited for melting bronze alloys.

TABLE 1 — STANDARD SPECIFICATIONS FOR 85-5-5-5 ACCORDING TO A.S.T.M. B62-52

	Chemical Requirements, %	
	Minimum	Maximum
Copper	84.0	86.0
Tin	4.0	6.0
Lead	4.0	6.0
Zinc	4.0	6.0
Nickel	—	1.0
Iron	—	0.30
Phosphorus	—	0.05
Tensile Requirements		
Tensile Strength, psi	minimum	30,000
Yield Strength, psi*	minimum	14,000
Elong. in 2 in., %	minimum	20

*Yield strength is determined as the stress producing an elongation under load of 0.5 per cent which is 0.01 in. in a gage length of 2 in.

Low frequency units such as were employed are especially good for brass and bronze melting because:

1. Melt losses incurred are low, thereby effecting significant savings in material costs. Also, good reproducibility is thereby provided; melt chemistry variation due to metal losses is minimized.
2. Furnaces inherently set up a stirring action in the metal which tends to reduce inhomogeneity in the bath.
3. The furnace is efficient in transferring electrical power to heat since the heat is generated in the metal itself. In a 6 month period (6,984,000 lb), the cost of power averaged \$6.44/ton, including

the cost of holding the furnaces on low power at night, during holidays and weekends.

4. Since metal is in the furnace at all times, thermal fluctuations are minimized so that the refractory life is excellent. The monolithic hand rammed linings, which are currently in service, have thus far been used for melting about 10,000,000 lb of metal. It appears that they will last for at least another two million lb.
5. Working conditions around the furnaces are comparatively good, since the temperature in the working area is low and the atmosphere relatively clean.

In general, the furnaces are best suited for melting one alloy. However, they may be used interchangeably between two similar alloys such as *M* Metal and 85-5-5-5.

The power input for the induction furnaces is dependent on the magnetic flux induced in the continuous loop of metal, illustrated in Fig. 1, which forms the secondary coil. The power input can be varied by applying a higher voltage. This is done by decreasing the number of effective turns on the furnace coil by means of tap switches. The power adjustment is used to compensate for alloys with different electrical conductivities. Several taps are provided so that the melting rate can be varied. A low voltage tap is also provided for holding the heat to prohibit metal solidification in the channel while the furnace is not in use for production.

Chemistry Control

In order to illustrate that the control of metal chemistry to close tolerances was possible, it was decided that the zinc content of the B-62 metal* would be monitored. Zinc was chosen because it is the most difficult element to control due to vaporization losses which occur. In addition to the regular chemical samples which are analyzed by wet chemistry in accordance with the A.S.T.M. material standards, one sample was cast from each of the two furnaces used to melt B-62 alloys for every 4 hr of operation, and analyzed for zinc using x-ray fluorescence. Figures 2 and 3 show a picture of the x-ray fluorescence unit and a schematic diagram of its operation, respectively.

X-ray fluorescence[13] is extremely useful, since the method analyzes for zinc directly with both good precision and accuracy. In addition, the method is not a function of the state of chemical combination of an element so that no chemical separations need be made as in wet chemical analysis. Analytical results may be obtained within 10 min after a sample is cast so that the unit can therefore be used for control purposes. Another advantage is that the specimens are undamaged by the analysis; thus "standard samples" have an indefinite life.

X-ray fluorescence is most useful for the elements which have characteristic wave lengths between 0.5 and 2.5 Å (1 Å = 10^{-8} meters).[13] This is due to the fact that longer wave lengths which are produced by the elements of lower atomic number are readily absorbed by both air and the counter window. Thus,

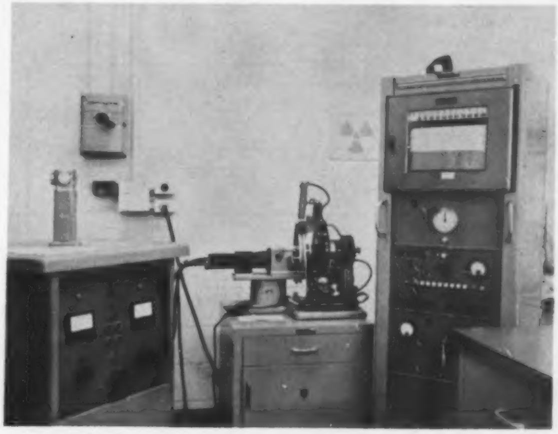


Fig. 2 — X-ray fluorescent equipment used for determining metal chemistry.

they are not easily measurable. The lower wave length limit which corresponds to the elements of higher atomic number is imposed primarily by the voltage placed on the x-ray tube, since high voltages must be used to excite short wave length high energy x-rays. Fortunately, due to the atomic constitution of the elements, the ones with high atomic numbers emit secondary characteristic x-rays in the desired range which although not as intense, can be excited with lower voltages and may be used for analysis.

Plant Operation

In order to see where improvements could be made in controlling metal chemistry, the flow of materials through the plant was examined. Figure 4 is a schematic diagram of the operation and shows that the charge consists of gates and sprues, scrap, chip, ingot and zinc. The diagram illustrates that a majority of

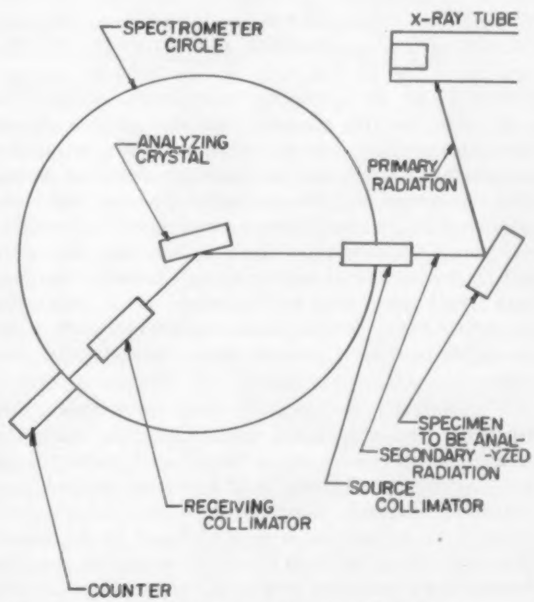


Fig. 3 — Schematic diagram of x-ray equipment.

*Deoxidized with 2 oz of 15 per cent copper phosphorus/100 lb of metal.

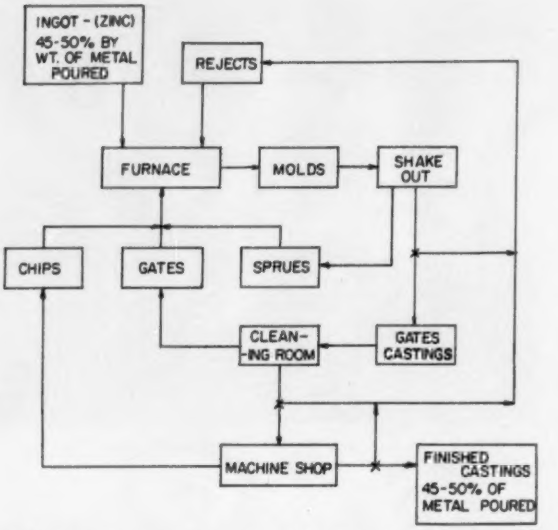


Fig. 4 — Schematic diagram of the flow of materials in the operation. Average production data for B62 — green sand — 475,000 lb/mo, yield 50-55 per cent; shell sand — 175,000 lb/mo, yield 40-45 per cent.

the charge components are recycled material, and that the only new components are ingot and zinc. Similarly, all the metal which leaves the system is in the form of good castings, melt loss and metal handling losses.

Obviously, to obtain a balanced system, the weight of metal added should equal the weight of metal leaving the system, namely, the castings, plus the losses which are incurred in the process by vaporization in the slag or in handling. Next, the flow of materials being recycled was studied to see if a definite pattern could be established.

Figure 4 illustrates that after the metal is poured, the sprue heads are accumulated and then returned to the melt. The cycle for this metal is the shortest, since these are accumulated and added in amounts not exceeding 10 per cent of the 1000 lb charges, within 24 hr of operating time after casting. The cycle time for the returns from the cleaning room fluctuates slightly, due to the amount of cutting that the castings require but are normally remelted within 48 hr of operation. The majority of chips which are produced in the machining operation will be recycled within 15 working days from the casting date. The last source of the charge material, namely, the castings which are found to be defective by inspections occurring between the processes outlined and shown as an *X* in Fig. 4, would have intermediate cycle times.

Theoretically, the system is ideal for chemical control purposes, since if the metal added to the system is within the composition limits and there are no preferential metal losses incurred, it is impossible to be out of chemical composition. Under actual conditions, if no mixed metal is introduced to the system, the only deviation from the ideal is due to melt loss incurred in both the slag and by vaporization. The latter is the most important for chemical control, since analysis of the slag has shown that the loss here for copper, zinc, lead and tin are in approximately the same ratio as in the base alloy. There is preferential removal of iron, however, and thus this constituent is the only one being reduced.

Chemistry Control

Thus, the chemistry of any major element may be controlled by adjusting the level of the new material and by compensating for any losses. On this basis, to stabilize the zinc content of the cast material a sufficient amount of zinc must be added to compensate for the zinc lost through vaporization, and the zinc level of the new material added to the system must also be adjusted to the desired final aim. It was found that the latter could be accomplished since the composition of the ingot is known. Thus, it was decided that the correct amounts would have to be determined empirically and that in time, if a consistent practice was used, the overall composition would approach a given quantity asymptotically.

The control system was put into effect first by marking the zinc content on each pallet of ingot (approx. 2000 lb) as it was received, using the certified chemical analysis supplied by the ingot manufacturer. The table, shown in Fig. 5, was then used to relate the various ingot compositions and amount of ingot in the charge to the weight of zinc which should be added. This was given in terms of a number of pure zinc blocks of known weight. The resulting addition which appeared to give the most consistent data for an aim of 5.5 per cent zinc allowed 8 lb/1000 (0.8 per cent zinc) for the zinc lost in

85-5-5-5 ZINC ADDITIONS FOR A 1000 LB CHARGE

Zn (Ingot), %	Weight of Ingot in 1000 lb Charge: 900	650	350
	No. Zinc Blocks		
5.7	3	3	3
5.6	3	3	3
5.5	3	3	3
5.4	3	3	3
5.3	3	3	3
5.2	3	3	3
5.1	4	3	3
5.0	4	4	3
4.9	4	4	3
4.8	4	4	3
4.7	5	4	3
4.6	5	4	4
4.4	5	5	4
4.3	6	5	4
4.2	6	5	4
4.1	6	5	4
4.0	6	5	4

No. Zinc Blocks	Weight, lb
3	10
4	13
5	16
6	19

Fig. 5 — Chart used to determine the proper zinc additions for ingots of varying zinc content.

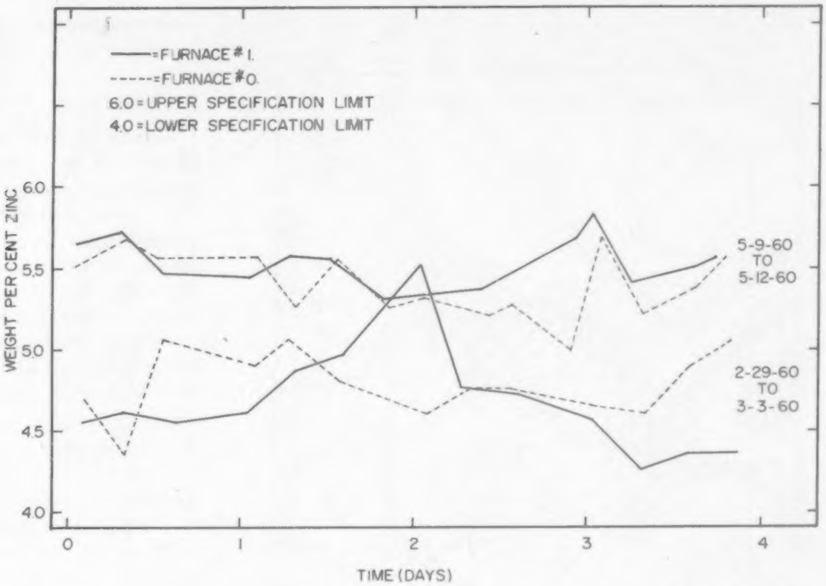


Fig. 6 — Plot of the zinc content in the B62 metal vs. time.

vaporization plus the amount of zinc necessary to bring the ingot composition up to 5.5 per cent.

Note that the figures were given for three different charges which had 350, 650 and 900 lb of ingot, respectively. This was done to cover any charge component shortage due to fluctuations in the flow of recycled materials. The results of the additions were followed daily by a plot of analyses versus time. Figure 6 is a plot made when the additions were just started and during a week nearer the end of the project, respectively.

In observing the plot of melt zinc content over a period of time, it was noted that a larger loss was incurred over the weekends. Experimentation showed the amount necessary for replenishing this loss amounted to 0.5 per cent of the metal in the furnace. Eventually, this amount was added early Monday mornings to compensate for the weekend vaporization losses.

Tensile and X-ray Tests

Since it was mandatory that the foundry properties of the alloy should not be negatively affected during standardization of the zinc content, data were obtained from the daily tensile test results and wet chemical analyses made in accordance with the A.S.T.M. chemical and physical requirements.

During the last four months the zinc chemistry was monitored by x-ray fluorescence. The advantage of this was that the bronze was analyzed for zinc directly rather than by difference, and also that the results could be obtained within 10 min of casting so that any changes due to furnace additions could be checked while the metal was still in the furnace and corrections could be made if necessary.

A working diagram for zinc is shown in Fig. 7. The reproducibility of the working diagram and x-ray analysis method was checked periodically. In addition to analyzing samples by wet chemistry in order to check the results, several other tests were made. One involved pouring a series of five test bars from the same crucible and analyzing the five samples. The results are given in Table 2. Note, that the standard deviation of the value obtained for the per cent Zn was only 0.04 per cent.*

TABLE 2 — ANALYSIS OF 5 SAMPLES

Sample	Avg. Time for 32,000 counts (sec)	Zn, %
1	42.5	4.96
2	42.4	4.97
3	42.5	4.96
4	42.2	5.02
5	42.0	5.06
Avg.	42.3	4.99
Standard Deviation	0.21	0.04

The condition of the surface of the specimen and its effect on the fluorescence results was also investigated. It was found that this could alter the analyses, since the amount of characteristic x-ray produced is a function of the area exposed to the primary radiation and the surface area exposed varies with the degree of surface polish. The cast samples, an example of which is shown in Fig. 8, were all finished on a 60 grit belt the same as the standard sample used to standardize the machine prior to each group of analyses, so that the surface area exposed remained constant.

It was also found that approximately $\frac{1}{64}$-in. or more of the surface of the cast specimen had to be removed in order to obtain reproducible analyses.

*The fact that x-ray fluorescence is influenced by the other alloying constituents is exhibited in Fig. 7, which shows a working diagram for B-61. Note that the slope of the curve changed. Thus, working diagrams have to be made for each series of alloys.

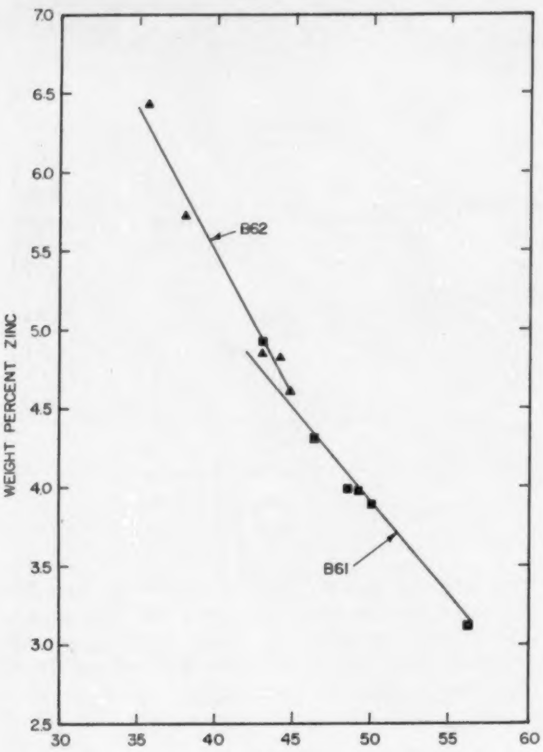


Fig. 7 — X-ray fluorescent analysis working diagram for the analysis of zinc in B61 or B62.

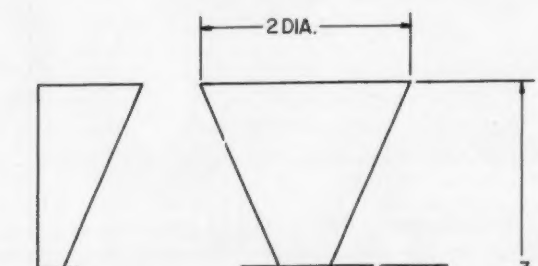


Fig. 8 — Cast sample specimen used for x-ray fluorescent analysis.

This was probably the result of segregation and surface defects.

Zinc Additions Results

Results of the zinc additions are shown in Fig. 9, which is a bar graph of the average zinc chemistry obtained by wet analysis for 10 months of operation. The curve also contains the average data obtained using fluorescent analysis. The largest deviation found for the monthly averages between the x-ray and wet chemistry was 0.15 per cent, which occurred in the first month that the x-ray tests were made. The variations were probably caused by the sample pieces not being taken simultaneously, and also because the wet zinc analysis is obtained by difference.

Corresponding standard deviations for the four months in which the fluorescent data were obtained exhibited a decrease, and are listed in Table 3. Note, that the deviation for the first two weeks of March was ± 0.28 per cent, while during the last two weeks of May the standard deviation was only ± 0.20 per cent.

TABLE 3 — STANDARD DEVIATIONS FOR FOUR MONTHS OF FLUORESCENT DATA

	Zn, %					
Month	Wet Analysis	X-Ray Analysis	Deviation	Y.S., psi	Elong., %	T.S., psi
Sept.	4.81			16,256	26.1	35,597
Oct.	4.75			16,265	26.0	35,308
Nov.	4.92			16,472	24.9	35,080
Dec.	4.94			16,464	26.0	35,476
Jan.	4.96			16,528	25.7	35,291
			284*			
Feb.	5.05	4.90	292	16,671	25.9	35,401
March	4.91	4.81	299	16,585	25.6	35,299
April	5.20	5.23	227	16,735	25.5	35,400
May	5.50	5.43	216	16,665	25.6	35,229
			200**			
June	5.51			16,857	24.8	35,301
$\bar{x}$	5.06			16,550	25.6	35,338
σ	267			194	477	140.6
r				+0.8	−0.5	−0.2

*First two weeks of Feb. using fluorescent analysis.
**Last two weeks of May using fluorescent analysis.

The plots, of the average monthly tensile, yield and per cent elongation vs. time, are illustrated in Figs. 10, 11 and 12, respectively. Each of these points is the average value of approximately 70 tests. These data show no significant change in either the average per cent elongation or tensile strength. However, the yield strength does increase noticeably.

To see if the change in any of the three mechanical properties measured were significant, linear correlation factors (Appendix) were calculated for all these variables versus the average zinc content. The wet chemical data were used in this case, since the fluorescent data were available for only 4 months, and the wet chemical samples were actually taken from the full Web test bar casting.

A value of 0.8 was obtained for the yield strength vs. the average zinc variation while values of −0.5 and

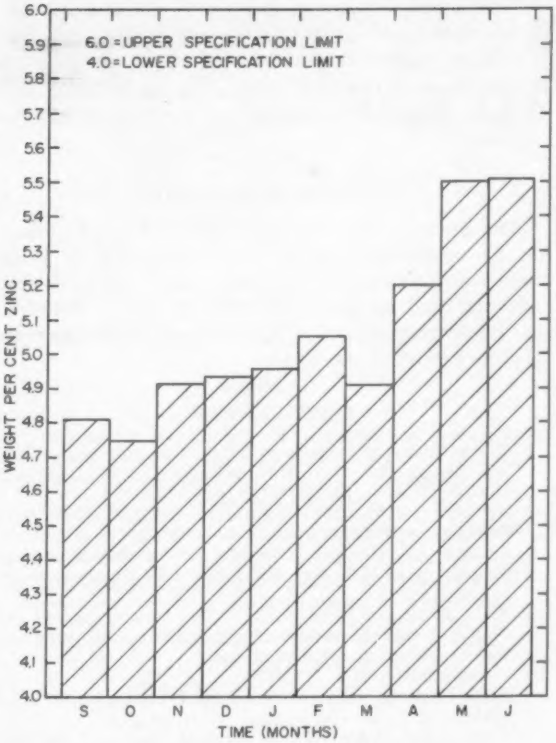


Fig. 9 — Bar graph of the average monthly zinc chemistry vs. time.

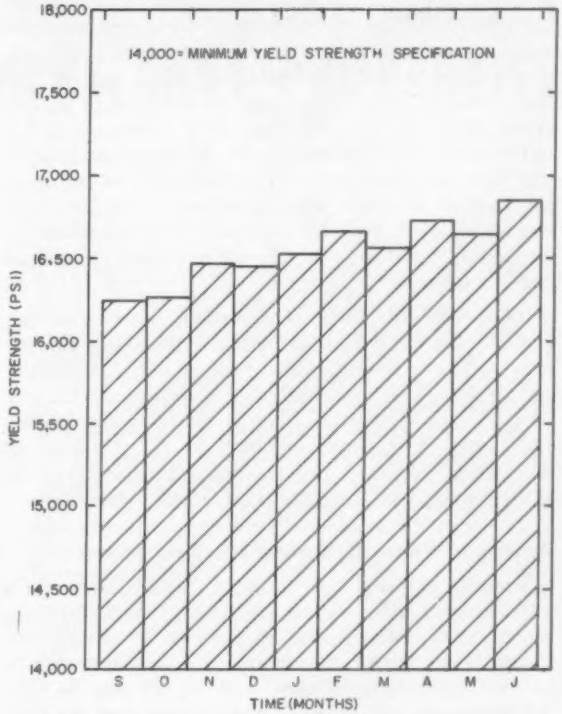


Fig. 11 — Bar graph of the average monthly yield strength vs. time.

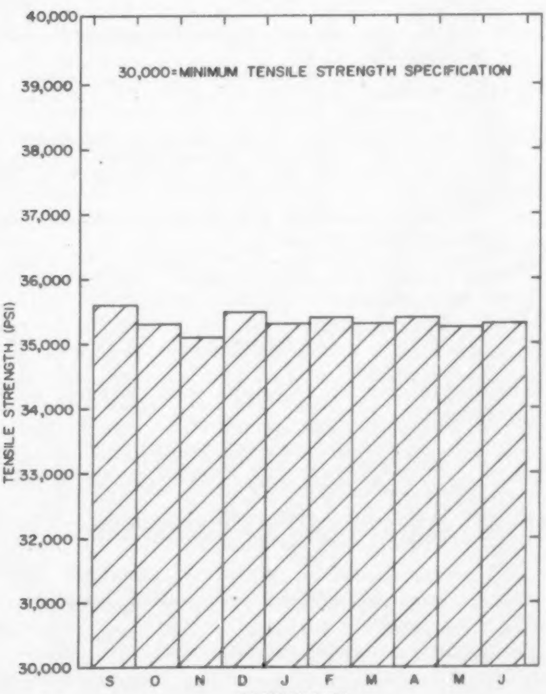


Fig. 10 — Bar graph of the average monthly tensile strength vs. time.

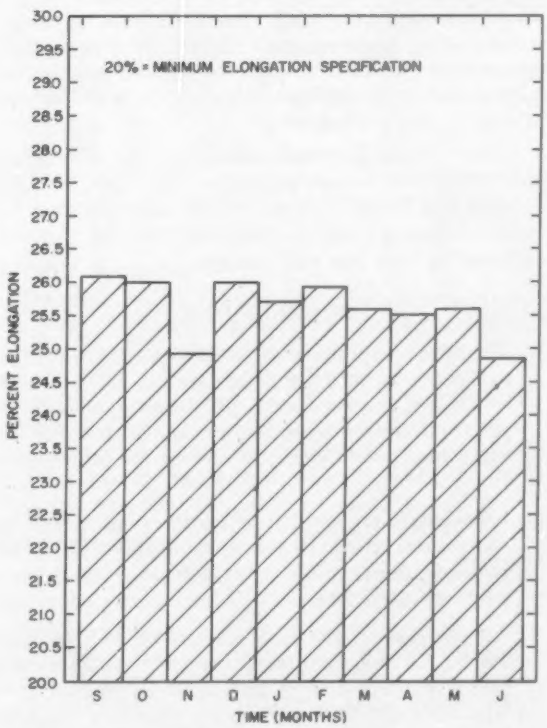


Fig. 12 — Bar graph of the average monthly per cent elongation vs. time.

−0.2 were obtained for both the tensile strength and per cent elongation, respectively. This signifies that the change in the yield strength with zinc content was significant. Throughout this last analysis, it is assumed that the other chemical variables, namely, the lead, tin and other impurities, do not change to any appreciable extent, and that their variation is insignificant and cancelled out by the large number of test bars and data taken. To check this assumption, the average monthly values for both tin and lead were calculated, and the standard deviation found to be under ±one per cent for tin and only ±0.06 per cent for lead.

Tests were also made to determine whether or not the zinc content had an appreciable effect on the fluidity of the 85-5-5-5 alloy. Several series of fluidity spirals were cast, and the results indicated that the zinc content had little effect in the allowable chemical range. The data corroborated the findings of Rosenberg, et al,[14] which indicated that pouring temperature was the most significant variable.

Economic Value of Raising the Zinc Content

Raising the zinc content to a higher level has a considerable effect on the cost of the final alloy. For example, over the period of time in which the zinc content was raised, the average zinc content was increased from approximately 4.8 to 5.5 per cent, or 0.7 per cent. Since in the plant's operation about 550,000 lb of castings are made monthly, this means that an additional 3850 lb of zinc were being used monthly. Thus, assuming that the increased zinc loss is offset by the decrease in the density of the alloy and neglecting both effects, 3850 lb of a material costing approximately $0.12 a lb is being substituted for the same amount of 85-5-5-5 which cost approximately $0.30, thus effecting a material cost saving of over $700/month.

Other advantages attributable to the system are that the control is more positive and the yield strength is increased while both the tensile strength and per cent elongation exhibit no marked decrease attributable to the increased zinc content.

CONCLUSIONS

1. The zinc composition of 85-5-5-5 can be controlled to close tolerance by compensating for zinc loss which in our case amounted to approximately 0.8 per cent, and by adjusting the composition of the input material to the level of the final composition desired.
2. Low frequency induction furnaces are ideal for controlling bronze chemistry in addition to providing low power costs, low melt losses and good working conditions.
3. An increase in the zinc content of 85-5-5-5 from 4.8 to 5.5 per cent amounts to a material cost saving of over $700 a month in an operation in which 550,000 lb of castings are produced monthly.
4. Increasing the zinc content of 85-5-5-5 from 4.8 to 5.5 per cent resulted in an increase of the average yield strength from 16,250 psi to 16,750 psi, without appreciably affecting the tensile strength, per cent elongation or fluidity.
5. The x-ray fluorescent method is an accurate and rapid means of obtaining zinc analyses in 85-5-5-5 alloy.

ACKNOWLEDGMENT

The authors wish to thank Prof. M. C. Flemings for his comments. Messrs. D. Winslow and J. Falco were instrumental in obtaining the many chemical analyses used in this work. Mr. R. Burns and Mr. L. Babb prepared the illustrations, and Miss R. Nelson prepared the drafts.

REFERENCES

1. Colton, Robert A., "Making Quality Brass and Bronze Castings Defects Due to Melting, Pouring, and Solidification," MODERN CASTINGS, *vol. 32*, p. 29 (July 1957).
2. St. John, H. M., "The Control of Quality in the Brass Foundry," AFS TRANSACTIONS, *vol. 67* (1959).
3. Ames, B. N., "Gating and Risering of Tin Bronze Castings Symposium on Principles of Gating," AFS TRANSACTIONS, p. 66 (April 24, 1951).
4. Ames, B. N. and Kahn, N. A., "Effect of Superheating and Casting Temperatures in Physical Properties and Solidification Characteristics of Tin Bronzes."
5. Unpublished data.
6. Boak, "Metallurgy in the Non-Ferrous Foundry," *Canadian Metals.*
7. Cook and Crowley, "The Control of Quality is the Production of Brass Ingots and Billets," *Journal Institute of Metals, vol. 81*, p. 341 (March 1953).
8. Evans, "Non-Ferrous Metals," *Extraction and Retaining, Reports in the Progress of Applied Chemistry, vol. 36* (1951).
9. Dodson, "Chemical Treatment of Molten Non-Ferrous Metals," *Canadian Metals, vol. 15*, pp. 32, 34, 35, 64 (May 1952).
10. Versagi, F. J., "Impurities in Copper Base Alloys," *Foundry*, p. 98 (Dec. 1955).
11. Schuhmann, R. Jr., "A Survey of the Thermodynamics of Copper Smelting," *Journal of Metals, A.I.M.E. Transactions, vol. 188* (June 1950).
12. Baer, W. H. and Loring, B. M., "Effects of Melting Atmosphere, Time at Temperature, and Degasification on Properties of Valve Bronze," AFS TRANSACTIONS, *vol. 57*, p. 257 (1949).
13. Cullity, B. D., *Elements of X-ray Diffraction*, Addison-Wesley Publishing Co., p. 406 (1956).
14. Rosenberg, R. A., Brody, H. D., Monkman, F. C. Jr., "Fluidity of 85-5-5-5 and Composition 'M' Metal," AFS TRANSACTIONS, *vol. 68*, p. 185 (1960).

APPENDIX

The linear correlation factors were obtained using the formula:

$$r = \frac{E\,(yi - \overline{yi})\,(xi - \overline{xi})}{n\,\sigma_x\,\sigma_y}$$

where r is the correlation coefficient.

Xi, yi are the two variables.

$\overline{Xi}$, $\overline{yi}$ are the means of the two variables.

σ_x, σ_y, are the standard deviation of x and y, respectively.

n is the number of pieces of data.

This will vary from −1 to +1, depending on whether the slope of a meaningful curve is positive or negative and will equal ±1 only if the points fall in a straight line.

MAGNESIUM-BASE ALLOYS INVESTMENT CAST PROPERTIES

by K. Herrick

ABSTRACT

Using the investment casting process, four magnesium-base alloys were evaluated — AZ92A, AZ91C, AZ81A and AM100A. Average grain size and massive compound ratings were determined as a function of section size, investment mold temperature and metal pouring temperature. Tensile properties were found to be approximately those obtained by sand casting methods. The alloys were classified according to their tendency toward microshrinkage as observed on ten typical production parts.

The author concludes that magnesium alloys AZ92A, AZ91C, AZ81A and AM100A can be cast satisfactorily in a variety of shapes common to the investment casting process for nonferrous alloys. Tensile properties of the four alloys exceed the minimum requirements of Government and aeronautical specifications. AZ91C alloy had the best combination of mechanical properties and castability for use with the investment casting process.

INTRODUCTION

The history of magnesium investment castings dates back to the middle of late 1940's. The feasibility of casting magnesium-base alloys in investment molds has been demonstrated in previous publications.[1,2,3,4] During the early years of production, magnesium parts were used primarily for weight saving. A large percentage of the castings were furnished in the as-cast condition and did not require radiographic or fluorescent penetrant inspection. Almost all parts were produced in alloy AZ92A. As engineers became more familiar with the investment casting process, structural parts were designed.

Mechanical properties and soundness were now of prime importance. This was evidenced by the publication during 1960 of Aeronautical Material Specification 4453 which covers investment castings in alloy AZ92A, T6 temper and a tentative specification for investment castings in alloy AM100A, T6 temper.

It is well known that the properties of cast magnesium alloys are quite sensitive to the rate of freezing as well as many other factors. The purpose of this work was to determine the tensile properties of four investment cast magnesium alloys, and to investigate some of the factors which influence the investment cast properties. The alloys selected were AZ92A, AZ91C, AZ81A and AM100A.

METHODS AND PROCEDURES

Mold Preparation

All investment molds were made using the lost wax process. The wax patterns were invested with a typical gypsum investment. This material consists of approximately 30 per cent plaster of paris and 70 per cent silica refractories. Water added to make the pouring slurry was 42 per cent of the weight of the dry investment. The slurry was vacuumed prior to and after pouring the investment in the flasks in order to remove trapped air bubbles. Borofluoride compounds were added to the slurry during mixing to inhibit reaction of the molten metal with the cured mold.

Wax removal, burnout (calcining at high temperature) and oven cooling of the molds to the proper temperature for casting were accomplished in an air circulating batch-type oven. Flask temperature was controlled to $\pm$ 20 F. The entire cycle took 18-24 hr, depending on the size of the mold.

Pressure for casting was obtained by applying suction on the surface of the mold opposite the sprue opening. Molds were flushed with sulfur dioxide immediately prior to casting.

Metal Preparation

One hundred lb charges of the alloys were melted in steel crucibles in a gas-fired furnace using the standard open pot melting practice. Commercially alloyed ingot was used to prepare all four alloys investigated. Chlorination for degassing and an addition of 20 grams of hexachlorabenzene at 1450 F for grain refinement were used on all alloys. The pouring temperature was adjusted in the casting ladle by chilling the metal with carbon rods.

Specimens and Testing

The standard 0.252 in. diameter, one in. gage length tensile specimen was used for all tensile tests.

These cast-to-size specimens were tested in accordance with American Society for Testing Materials standards for separately cast bars. The test bars were cast vertically, four in 5 in. diameter by 7 in. mold, using the rigging shown in Fig. 1.

Average grain sizes and compound ratings were determined for all alloys in the heat treated condition

K. HERRICK is Chief, Engrg. Dept., Tilton Div., Arwood Corp., Tilton, N.H.

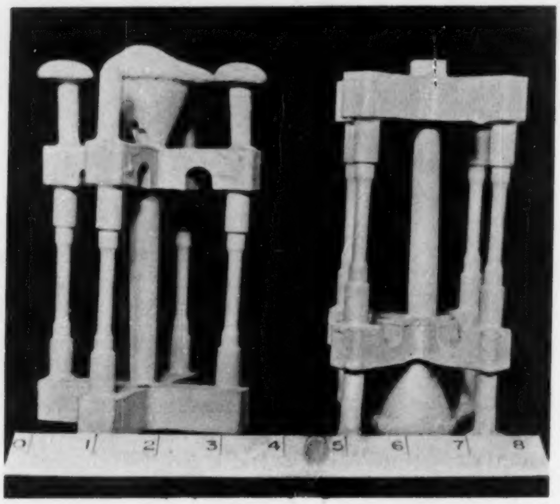


Fig. 1 — Rigging used on 0.252 in. diameter investment cast test bars.

according to the procedures outlined by George.[5] Specimens for microscopic examination were obtained from cast slugs of 1/8, 1/4, 1/2 and 3/4-in. diameter by 4-in. long. The observed area was a transverse section located approximately one in. from the end opposite the sprue opening. The rigging used for the cast slugs is shown in Fig. 2.

Radiographs were taken using a 160 kv unit which has a 2.4 mm focal spot. A fine grained industrial quality film was used. Radiographs were compared to the standards of American Society for Testing Materials Specification E98-53T.

Heat Treatment

Specimens were solution heat treated in an electrically heated circulating air furnace whose atmosphere contained a minimum of 0.5 per cent sulfur dioxide. Alloy AZ92A castings were solution heat treated using the following anti-germination schedule:

1. Castings were held 6 hr at 765 ± 5 F.
2. Temperature was reduced to 665 ± 5 F and held for 2 hr.
3. Temperature was raised to 765 ± 5 F and held for 10 hr.
4. Air quench.

Alloy AZ91C, AZ81A and AM100A castings were solution heat treated using the following anti-germination schedule:

1. Castings were held 6 hr at 775 ± 5 F.
2. Temperature was reduced to 665 ± 5 F and held for 2 hr.
3. Temperature was raised to 775 ± 5 F and held for 10 hr.
4. Air quench.

Artificial aging was applied in the same furnace used for solution heat treatment.

RESULTS

Compound ratings and average grain sizes were determined for each alloy at each of three mold temperatures, two pouring temperatures and the four section sizes previously described. The results are listed in Table 1.

Tables 2 through 5 summarize the effect of investment mold temperature and pouring temperature on the tensile properties of the alloys.

The tensile yield strength, ultimate strength and elongation of AZ92A, AZ91C and AM100A are presented as a function of aging time for a series of four aging temperatures in Figs. 3 to 14, inclusive. Investment mold temperature was 70 F and pouring temperature was 1240 F for all test bars in this aging test.

An evaluation of the castability of the four alloys was based on the visual and radiographic results of the ten different castings shown in Figs. 15 through 17. Visual appearance of all the alloys was the same. Table 6 summarizes the radiographic results of the ten castings produced in the various alloys. All castings were graded only on microshrinkage. Rigging, flask temperature and pouring temperature was held constant even though the alloy was changed or several alloys were used for the same part to compare radiographic quality.

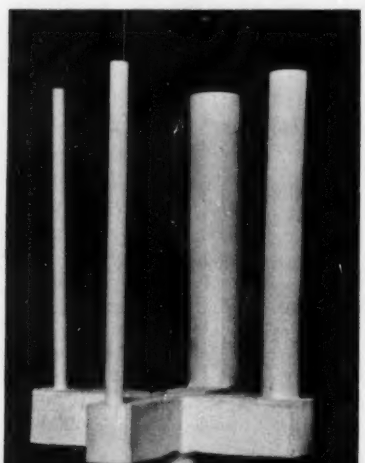


Fig. 2 — Rigging used on 1/8, 1/4, 1/2 and 3/4-in. diameter investment cast slugs.

DISCUSSION OF RESULTS

Investment mold temperature, metal pouring temperature and section size had minor affects on the average grain size of all alloys investigated. An arbitrary dividing line set by some sand casting foundries between fine and coarse grain diameter in a 0.505

TABLE 1 — INVESTMENT MOLD TEMPERATURE, POURING TEMPERATURE AND SECTION SIZE EFFECT ON THE AVERAGE GRAIN SIZE AND COMPOUND RATING OF FOUR HEAT TREATED MAGNESIUM ALLOYS

Alloy	Mold Temp., F	Pouring Temp., F	Avg. grain dia. at various section sizes (x 10-3 in.) ⅛	¼	½	¾	Compound rating at various section sizes ⅛	¼	½	¾
AZ92A	650	1360	3	4	4	4	3	4	6	8
	650	1240	3	3	4	4	3	4	5	7
	400	1360	3	3	4	4	1	3	4	6
	400	1240	3	4	4	5	1	3	4	6
	70	1360	3	3	3	3	1	2	4	5
	70	1240	3	3	3	4	1	2	4	6
AZ91C	650	1360	3	3	3	3	1	1	3	4
	650	1240	3	3	3	4	1	1	4	5
	400	1360	3	3	4	4	1	1	3	4
	400	1240	2	3	3	2	1	1	3	4
	70	1360	3	4	4	4	1	1	3	3
	70	1240	3	3	3	3	1	1	2	3
AZ81A	650	1360	3	3	3	4	1	2	3	5
	650	1240	3	3	3	3	1	2	2	4
	400	1360	3	3	3	3	1	1	2	4
	400	1240	3	4	3	3	1	1	2	3
	70	1360	3	3	3	3	1	1	2	3
	70	1240	3	3	3	3	1	1	2	3
AM100A	650	1360	3	3	3	4	1	2	6	7
	650	1240	3	4	4	3	1	1	5	7
	400	1360	3	3	4	4	1	2	5	7
	400	1240	3	4	4	4	1	2	5	6
	70	1360	4	3	4	4	1	2	5	6
	70	1240	2	2	3	4	1	1	5	6

Analysis of Metal

	AZ92A	AZ91C	AZ81A	AM100A
Al, %	8.95	8.64	7.87	10.10
Zn, %	2.10	0.56	0.94	0.11
Mn, %	0.20	0.22	0.24	0.22

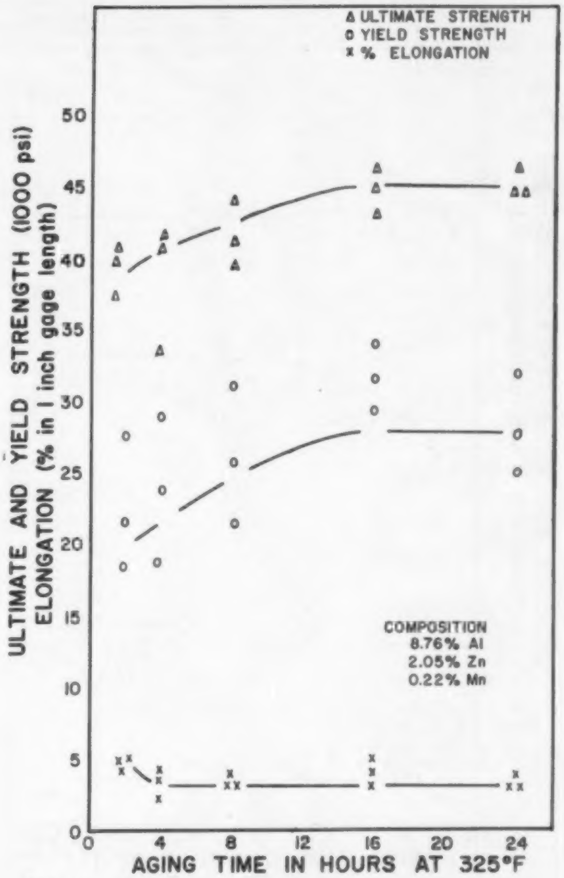


Fig. 3 — Tensile properties of investment cast AZ92A, solution treated and aged at 325 F.

TABLE 2 — INVESTMENT MOLD AND POURING TEMPERATURE EFFECT ON THE TENSILE PROPERTIES OF AZ92A

Chemical Composition	Mold Temp., F	Pouring Temp., F	Temper	No. of Bars	Avg. Properties TS, ksi	YS, ksi	E, %	Range of Properties TS, ksi	YS, ksi	E, %
B	650	1360	T6	4	28.8	22.0	1.0	26.1-31.9	20.7-23.4	1.0
B	650	1240	T6	4	37.2	20.1	2.8	32.7-38.3	17.5-21.8	2.0-3.0
A	400	1360	T6	4	37.6	24.0	2.4	36.9-38.2	22.5-25.5	2.0-3.0
A	400	1240	T6	3	40.8	25.8	2.5	38.8-42.1	25.1-26.2	2.0-3.0
A	70	1360	T6	4	35.2	23.2	2.0	34.1-37.5	21.5-26.8	2.0
A	70	1240	T6	4	41.9	25.7	2.8	41.6-42.4	23.4-27.4	2.5-3.0
B	650	1360	T4	4	28.7	13.5	3.3	28.3-29.0	13.4-13.7	3.0-4.0
B	650	1240	T4	3	35.4	13.9	7.7	34.3-36.6	13.8-14.0	6.5-9.0
A	400	1360	T4	3	35.4	14.8	6.2	34.4-36.4	14.3-15.4	6.0-6.5
A	400	1240	T4	4	36.5	15.6	6.2	35.7-36.7	14.1-16.3	5.0-7.0
A	70	1360	T4	4	34.4	16.6	7.5	34.2-34.6	14.3-18.2	7.0-8.0
A	70	1240	T4	4	40.3	16.1	7.5	39.1-41.5	13.9-18.5	7.0-8.0
A	70	1240	F	4	27.4	—	3.0	26.8-27.8	—	2.0-4.0

Heat treatment: T4, 16 hr at 765 F.
T6, 16 hr at 765 F and 5 hr at 425 F.

Chemical Composition

	A	B
Al, %	8.95	9.60
Zn, %	2.10	2.16
Mn, %	0.20	0.22

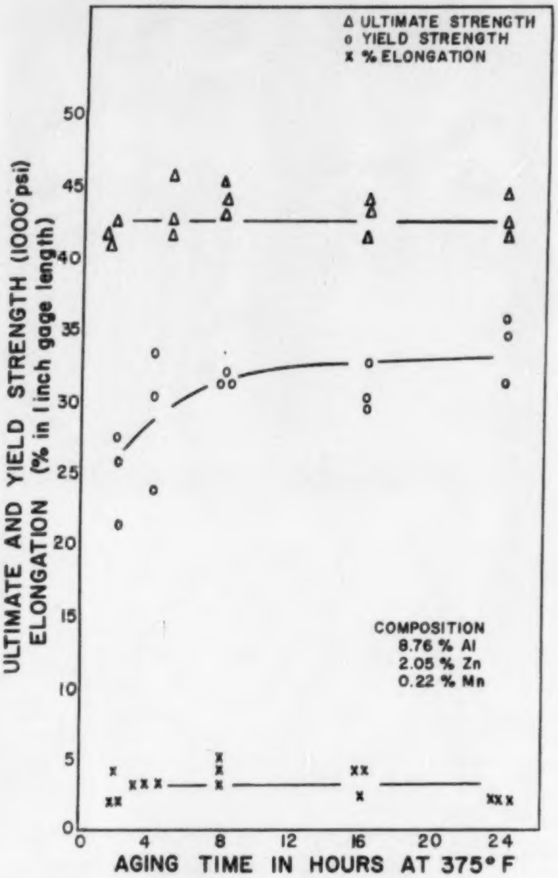


Fig. 4 — Tensile properties of investment cast AZ92A, solution treated and aged at 375 F.

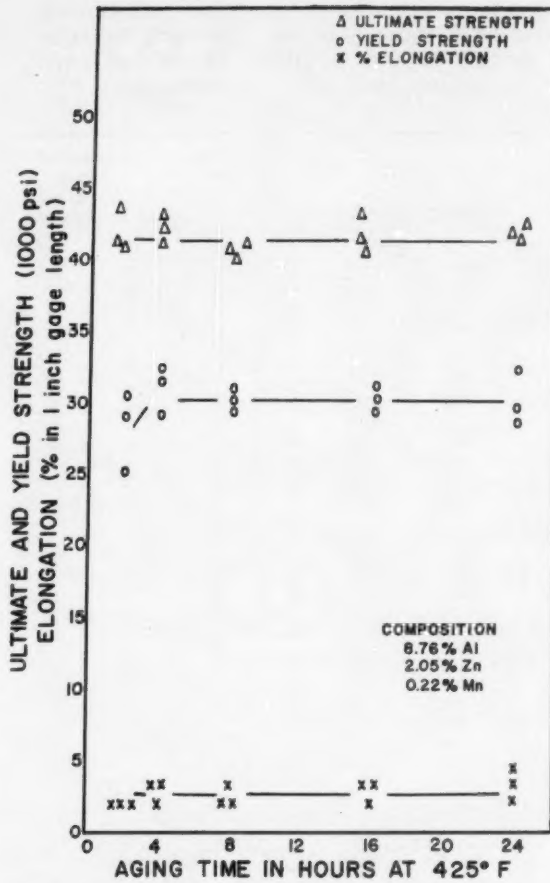


Fig. 5 — Tensile properties of investment cast AZ92A, solution treated and aged at 425 F.

TABLE 3 — INVESTMENT MOLD AND POURING TEMPERATURE EFFECT ON THE TENSILE PROPERTIES OF AZ91C

Chemical Composition	Mold Temp., F	Pouring Temp., F	Temper	No. of Bars	Avg. Properties			Range of Properties		
					TS, ksi	YS, ksi	E, %	TS, ksi	YS, ksi	E, %
A	650	1360	T6	4	38.1	20.9	4.5	36.7-39.8	18.4-24.2	4.0-5.0
A	650	1240	T6	4	33.3	20.5	3.0	31.4-36.9	18.2-24.4	2.0-4.0
A	400	1240	T6	4	35.9	20.0	3.0	34.9-37.0	17.4-21.8	2.0-4.0
A	70	1360	T6	3	35.7	23.6	3.0	34.2-37.1	20.0-26.2	2.0-4.0
A	70	1240	T6	3	36.0	22.7	3.6	35.6-36.2	19.1-26.3	3.0-4.0
A	650	1360	T4	4	35.4	13.1	9.0	35.3-35.5	11.8-14.4	8.0-10.0
A	650	1240	T4	4	35.0	11.7	9.0	34.8-35.2	10.5-12.9	9.0
A	400	1360	T4	4	35.6	13.9	8.0	34.9-36.4	13.8-14.1	7.0-9.0
A	400	1240	T4	4	34.9	14.1	9.0	34.2-35.8	13.9-14.4	9.0
A	70	1360	T4	3	37.3	14.4	10.3	36.7-38.0	13.5-15.3	10.0-11.0
A	70	1240	T4	3	37.7	14.1	11.6	35.8-38.9	13.9-14.4	11.0-13.0
A	70	1240	F	4	28.7	—	2.5	27.7-29.2	—	2.0-3.0

Heat treatment: T4, 16 hr at 775 F.
T6, 16 hr at 775 F and 16 hr at 335 F.

Chemical Composition

	A
Al, %	8.64
Zn, %	0.56
Mn, %	0.22

TABLE 4 — INVESTMENT MOLD AND POURING TEMPERATURE EFFECT ON THE TENSILE PROPERTIES OF AZ81A

Chemical Composition	Mold Temp., F	Pouring Temp., F	Temper	No. of Bars	Avg. Properties			Range of Properties		
					TS, ksi	YS, ksi	E, %	TS, ksi	YS, ksi	E, %
A	650	1360	T4	9	33.6	15.4	9.4	30.7-35.7	11.2-17.9	9.0-15.0
A	650	1240	T4	7	34.4	11.6	10.8	33.2-35.8	10.8-12.1	9.0-14.0
A	400	1360	T4	4	36.5	13.2	12.7	36.3-36.8	12.8-14.0	12.0-13.0
A	400	1240	T4	4	35.5	13.3	11.5	34.6-36.1	12.5-15.3	11.0-12.0
A	70	1360	T4	5	36.5	14.5	14.0	35.9-36.8	13.2-15.7	13.0-15.0
A	70	1240	T4	5	36.1	13.5	12.0	35.1-36.7	11.7-15.0	11.0-14.0
B	650	1360	F	4	26.3	—	2.1	25.4-27.4	—	1.5-3.0
B	650	1240	F	4	28.5	—	3.1	27.2-29.6	—	2.5-4.0
B	400	1360	F	4	23.3	—	1.6	22.1-24.3	—	1.0-2.0
B	400	1240	F	4	32.1	—	5.0	31.4-32.6	—	4.5-5.5
B	70	1360	F	4	28.3	—	4.0	25.7-30.0	—	2.0-5.0
B	70	1240	F	4	31.3	—	4.9	29.7-33.0	—	4.0-5.5

Heat treatment: T4, 16 hr at 775 F.

Chemical Composition

	A	B
Al, %	7.70	7.76
Zn, %	0.65	0.80
Mn, %	0.24	0.24

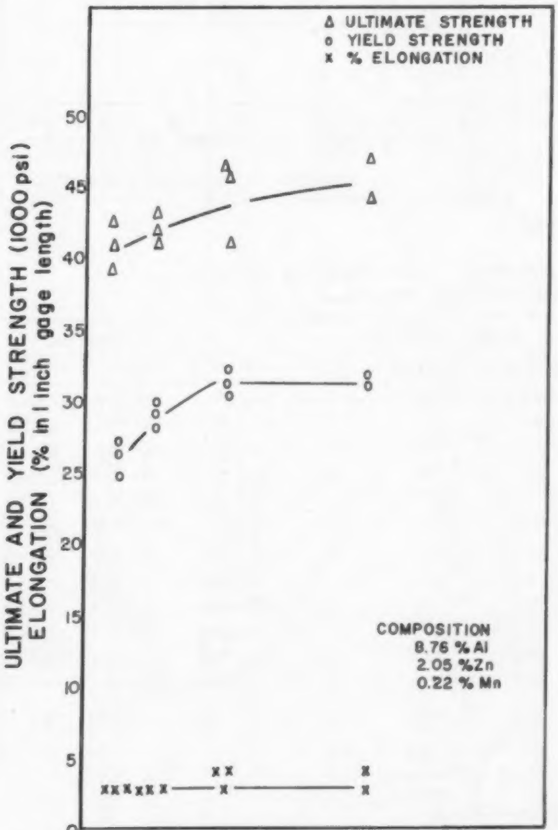


Fig. 6 — Tensile properties of investment cast AZ92A, solution treated and aged at 450 F.

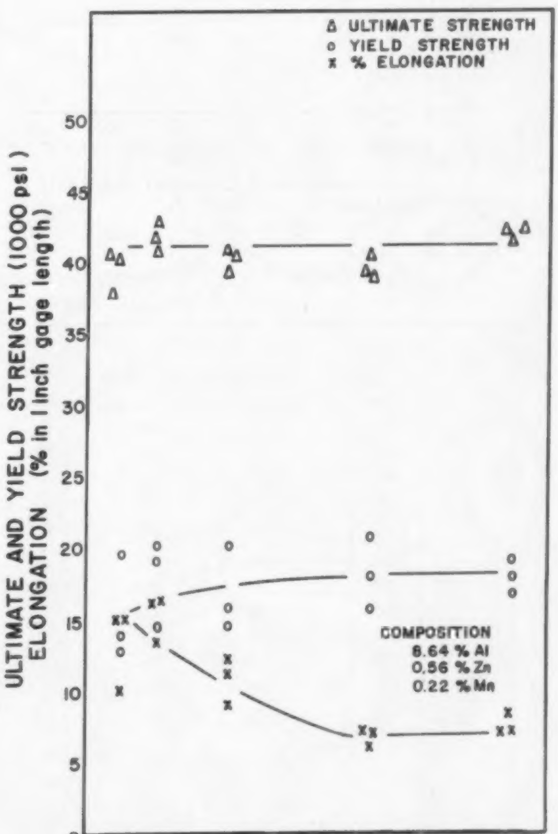


Fig. 7 — Tensile properties of investment cast AZ91C, solution treated and aged at 325 F.

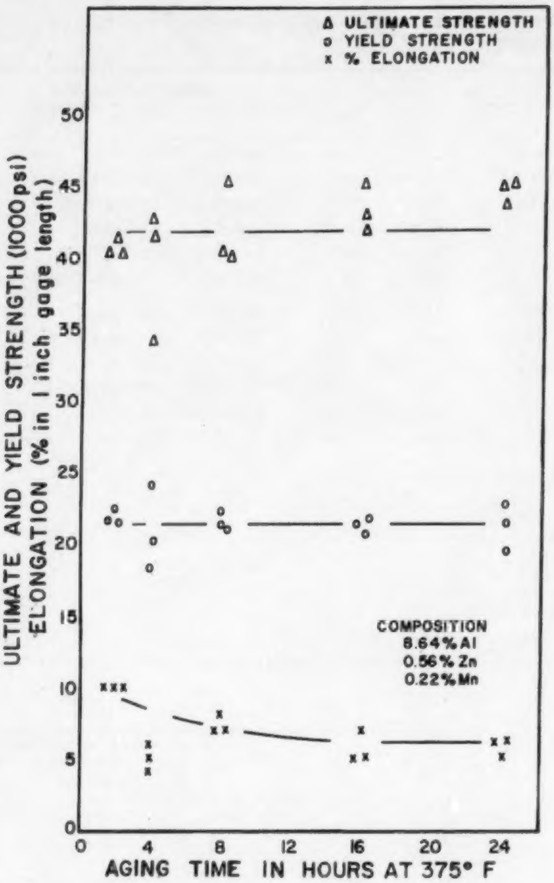


Fig. 8 — Tensile properties of investment cast AZ91C, solution treated and aged at 375 F.

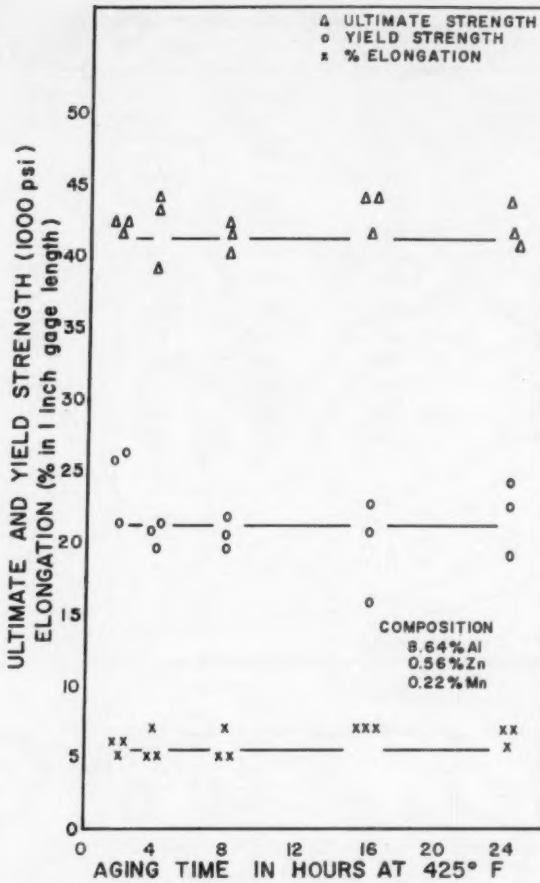


Fig. 9 — Tensile properties of investment cast AZ91C, solution treated and aged at 425 F.

TABLE 5 — INVESTMENT MOLD AND POURING TEMPERATURE EFFECT ON THE TENSILE PROPERTIES OF AM100A

Chemical Composition	Mold Temp., F	Pouring Temp., F	Temper	No. of Bars	Avg. Properties			Range of Properties		
					TS, ksi	YS, ksi	E, %	TS, ksi	YS, ksi	E, %
A	650	1360	T6	5	27.8	19.0	3.0	24.3-29.5	15.9-20.9	2.0-4.0
A	650	1240	T6	6	34.8	20.3	4.3	31.5-36.1	19.1-21.1	4.0-5.0
A	400	1360	T6	6	30.3	27.6	3.3	29.2-31.6	26.6-29.2	3.0-5.0
A	400	1240	T6	6	30.3	25.7	2.7	28.5-31.7	23.1-28.4	2.0-3.0
A	70	1360	T6	6	34.0	27.9	3.3	30.7-34.9	23.6-30.7	1.0-5.0
A	70	1240	T6	6	35.5	28.2	3.7	31.5-37.6	26.1-30.6	3.0-4.0
A	650	1360	T61	6	28.8	22.4	3.7	27.2-30.0	17.7-26.4	3.0-4.0
A	650	1240	T61	6	34.5	27.1	3.7	33.6-36.1	21.7-30.3	3.0-4.0
A	400	1360	T61	4	30.0	25.6	2.0	29.5-31.0	24.0-27.4	1.0-3.0
A	400	1240	T61	6	33.5	26.9	4.0	31.2-35.4	24.2-28.7	3.0-5.0
A	70	1360	T61	6	33.4	27.8	5.3	31.3-35.2	25.1-30.9	4.0-7.0
A	70	1240	T61	6	36.7	25.9	4.5	33.0-36.8	21.8-29.7	3.0-7.0
A	70	1240	F	4	28.2	—	3.0	26.7-20.3	—	3.0

Heat treatment: T6, 16 hr at 775 F and 10 hrs at 400 F.
T61, 16 hr at 775 F and 24 hr at 400 F.

Chemical Composition

	A
Al, %	10.00
Zn, %	0.06
Mn, %	0.24

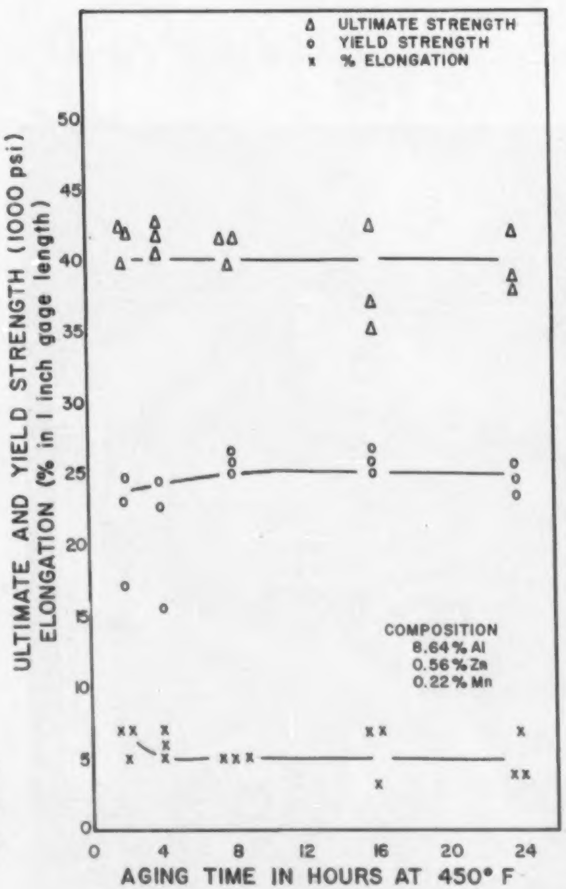


Fig. 10 — Tensile properties of investment cast AZ91C, solution treated and aged at 475 F.

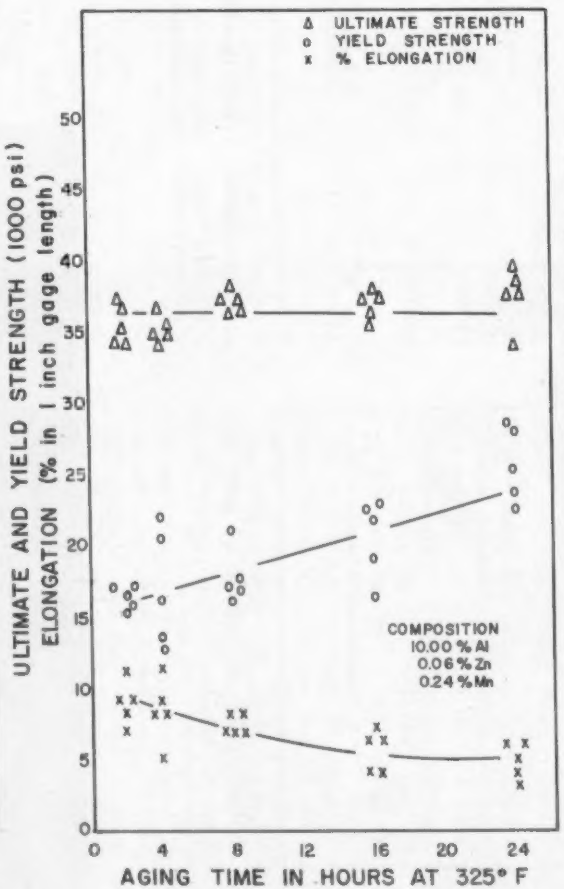


Fig. 11 — Tensile properties of investment cast AM100A, solution treated and aged at 325 F.

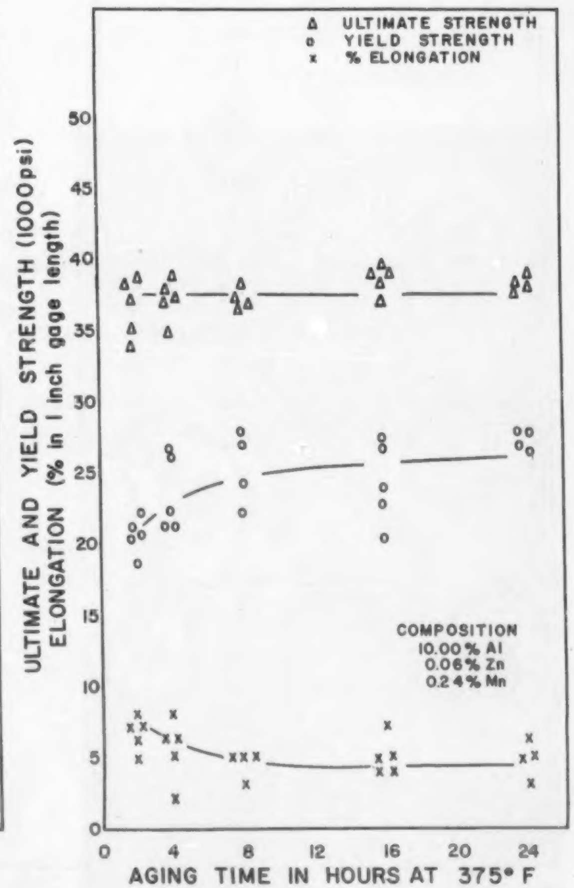


Fig. 12 — Tensile properties of investment cast AM100A, solution treated and aged at 375 F.

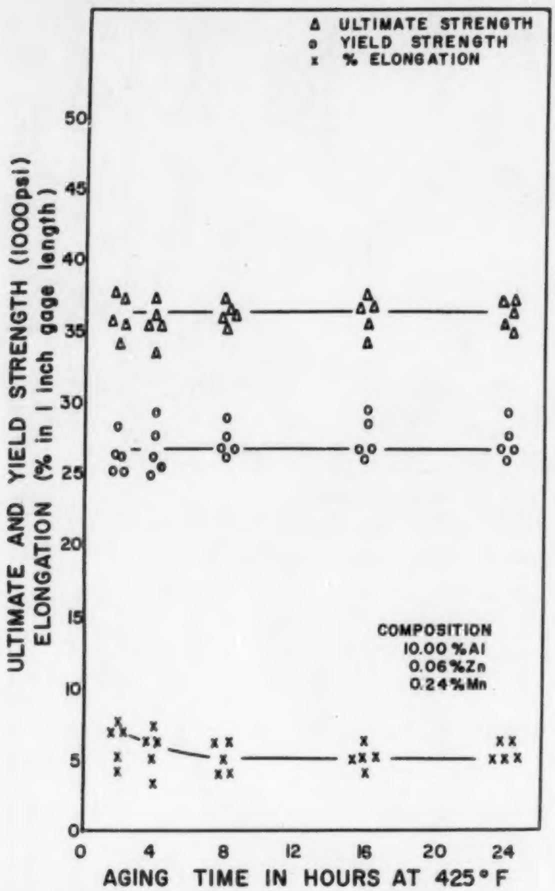


Fig. 13 — Tensile properties of investment cast AM100A, solution treated and aged at 425 F.

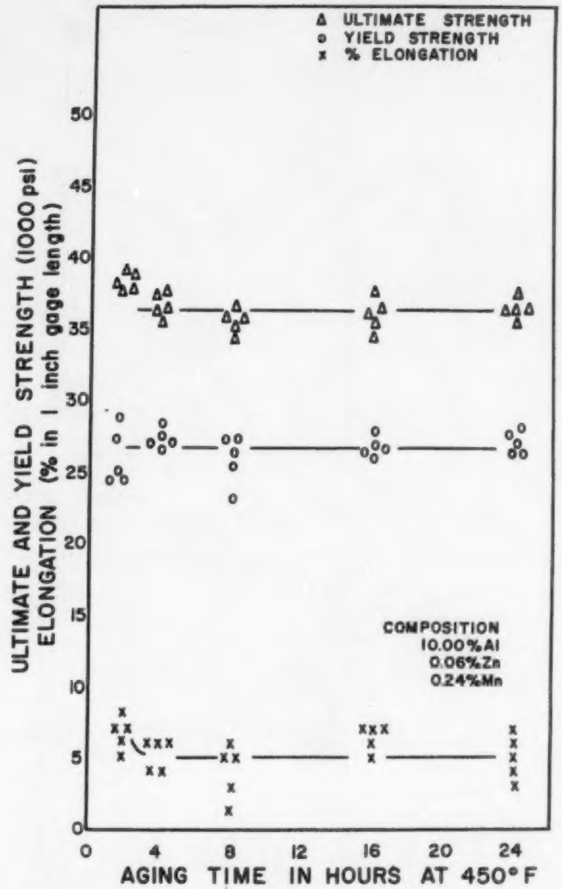


Fig. 14 — Tensile properties of investment cast AM100A, solution treated and aged at 450 F.

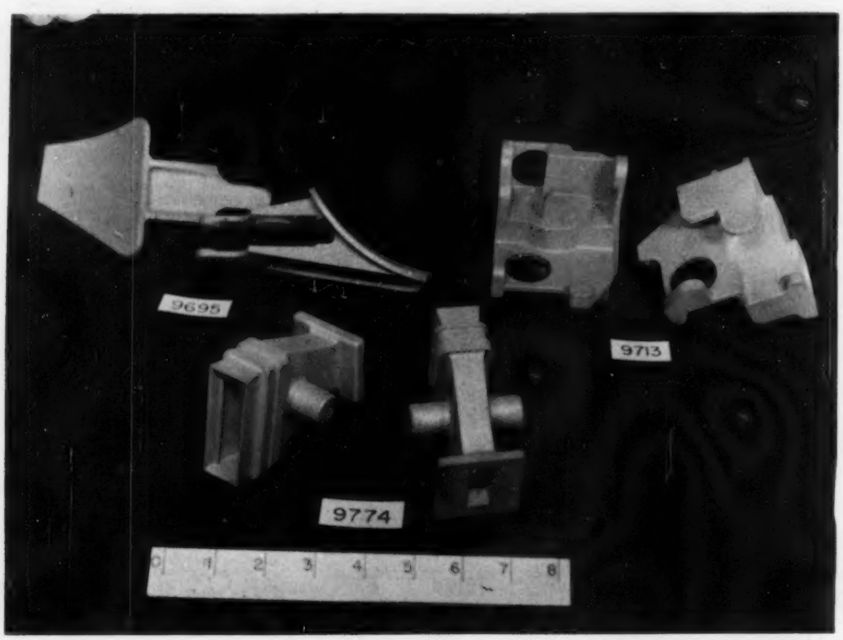


Fig. 15 — Investment cast magnesium alloy parts 9774, 9713 and 9695.

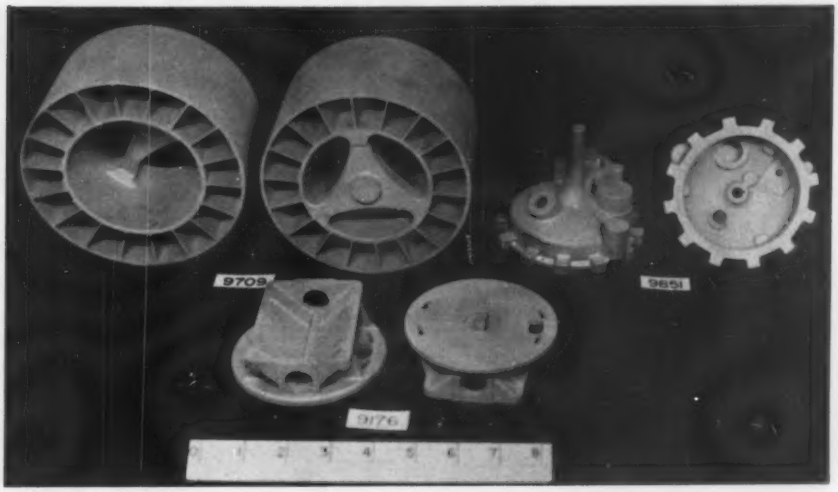


Fig. 16 — Investment cast magnesium alloy parts 9176, 9709 and 9851.

in. diameter test bar is 0.007 in. The observed level of 0.002 to 0.005 in. average grain diameter would be considered fine grained. This level of grain size was maintained with all solidification conditions studied. The amount of massive compound retained after solution treatment varied considerably depending on the alloy, casting conditions and section size of the specimen.

Increasing the section size resulted in greater increases in massive compound than did changes in investment mold temperature or metal pouring temperature. As might be expected, the least amount of massive compound for all alloys was obtained when the investment mold temperature and metal pouring temperature were low. The least amount of massive compound for all experimental conditions was obtained from alloy AZ81A followed by AZ91C, AM-100A and AZ92A, respectively.

Increasing the investment mold temperature from 70 to 650 F and the pouring temperature from 1240 F to 1360 F had a deteriorating effect on the average mechanical properties of all alloys and tempers investigated. This effect was the most serious on alloys AZ92A and AM100A, and was of little, if any, consequence on alloys AZ91C and AZ81A. All test bars were examined radiographically after heat treatment and prior to tensile testing. Test bars with gross defects were discarded prior to testing. Radiography revealed no differences in soundness as a function of casting conditions for any of the alloys.

Variations in property levels as a result of changes made in casting conditions were a function of undissolved compound after heat treatment. The largest decrease in properties occurred when the pouring temperature was increased from 1240 F to 1360 F using a 650 F mold temperature. The microstructure of the heat treated test bars with low properties contained a considerably greater amount of undissolved compound as compared to the test bars with higher properties. Metallographic examination was performed on selected test bars of each alloy representing the lowest and the highest properties obtained. This examination revealed that all structures were fine grained and free of porosity voids, but that the massive compound varied considerably.

The massive compound rating of AM100A test bars with low mechanical properties was five to six, as compared to two to three for test bars with the higher mechanical properties. Massive compound rating of AZ92A test bars with low mechanical properties was seven to eight as compared to three to four for test bars with the higher mechanical properties. No effort was made during the course of this work to improve on this condition through changes in heat treating cycles or other special procedures, as this would distract from the primary objective of direct comparison of the four alloys and the casting variables involved.

Optimum properties of AZ92A and AM100A were obtained after solution treatment and aging 4 hr at 425 F. Optimum properties of AZ91C were obtained after solution treatment and aging 8 hr at 450 F. Properties corresponding to this treatment were:

	Typical Tensile Properties		
Alloy	Ultimate, psi	Yield, psi	% Elong.
AZ92A	40,000	28,000	2.0
AZ91C	40,000	25,000	5.0
AM100A	35,000	25,000	5.0

The ten castings selected for radiographic comparison using the four different alloys represent a cross-section of the type of castings currently being produced in production. It should be noted that in all cases, except part 9709, AZ92A had a greater tendency toward microshrinkage than any of the other three alloys. It would be incorrect to assume that most AZ92A castings would normally fall in the category of number two to number four microshrinkage, as implied from Table 6. Modifications in the rigging and casting conditions would improve the quality of the parts cast in AZ92A.

However, these modifications would not be necessary for alloys AZ91C, AZ81A and AM100A. As a

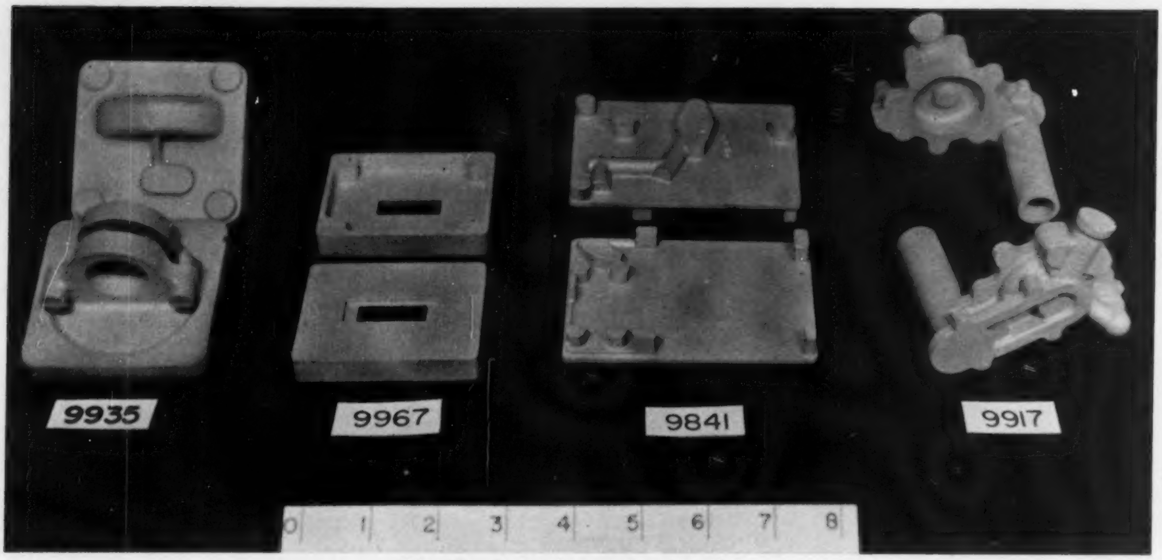


Fig. 17 — Investment cast magnesium alloy parts 9935, 9967, 9841 and 9917.

TABLE 6 — RADIOGRAPHIC RESULTS OF TEN PRODUCTION PARTS GRADED ACCORDING TO MAGNESIUM ALLOY USED AND MICROSHRINKAGE LEVEL

				Number of parts with degree of microshrinkage per ASTM E98-53T, Par. 2.3, No. 1 through 6						
Part No.	Pieces x-rayed	No. of Heats	Alloy	None	1	2	3	4	5	6
9774	4	1	AZ81A	0	4	0	0	0	0	0
9774	4	1	AZ91C	0	4	0	0	0	0	0
9774	4	1	AM100A	3	1	0	0	0	0	0
9774	38	4	AZ92A	0	0	15	23	0	0	0
9695	4	1	AZ81A	0	1	3	0	0	0	0
9695	4	1	AZ91C	3	1	0	0	0	0	0
9695	3	1	AM100A	2	1	0	0	0	0	0
9695	36	2	AZ92A	0	6	30	0	0	0	0
9709	3	1	AZ81A	0	3	0	0	0	0	0
9709	3	1	AZ91C	0	3	0	0	0	0	0
9709	3	1	AM100A	0	3	0	0	0	0	0
9709	24	6	AZ92A	0	24	0	0	0	0	0
9935	6	1	AM100A	0	6	0	0	0	0	0
9935	68	4	AZ92A	0	0	27	41	0	0	0
9713	8	2	AM100A	0	8	0	0	0	0	0
9713	119	15	AZ92A	0	0	0	119	0	0	0
9851	4	1	AM100A	0	4	0	0	0	0	0
9851	6	2	AZ92A	0	0	0	6	0	0	0
9841	8	2	AM100A	3	5	0	0	0	0	0
9841	604	38	AZ92A	80	23	450	51	0	0	0
9917	4	1	AM100A	0	0	4	0	0	0	0
9917	92	17	AZ92A	0	0	10	21	61	0	0
9176	44	4	AZ91C	8	32	4	0	0	0	0
9176	6	2	AZ92A	0	0	0	4	2	0	0
9967	45	2	AZ91C	12	22	11	0	0	0	0
9967	607	11	AZ92A	0	0	316	81	210	0	0

result of careful review of all radiograph film, alloy AM100A appeared to have the least tendency toward microshrinkage. Alloys AZ91C and AZ81A occupy an intermediate category followed by AZ92A which had the greatest tendency toward microshrinkage. This classification is in agreement with work done on sand castings by Hanawalt, Nelson and Busk.[6]

CONCLUSIONS

On the basis of the experimental evidence it is concluded that:

1. Magnesium alloys AZ92A, AZ91C, AZ81A and AM-100A can be cast satifactorily in a variety of shapes common to the investment casting process for other nonferrous alloys.
2. Tensile properties of all four alloys exceed the minimum requirements of applicable Government and Aeronautical Material Specifications.
3. Of the four alloys studied, AZ91C had the best combination of mechanical properties and castability for use with the investment casting process.

REFERENCES

1. P. L. Butler, "Magnesium Investment Castings," *Proceedings of the 8th Annual Meeting of the Magnesium Association*, New York (1952).
2. John B. Cambell, "Magnesium Investment Castings Save Weight," *Materials and Methods* (Jan. 1955).
3. R. L. Wood and D. Von Ludwig, *Investment Casting for Engineers*, Reinhold Publishing Corp., New York (1952).
4. Robert H. Hermann, *How to Design and Buy Investment Castings*, Investment Casting Institute, Chicago (1959).
5. P. F. George, "Metallography of Cast Magnesium Alloys," AFS Transactions, *vol. 57*, p. 133 (1949).
6. J. D. Hanawalt, C. E. Nelson and R. S. Busk, "Properties and Characteristics of Common Magnesium Alloys," AFS Transactions, *vol. 53*, p. 77 (1945).

THE CARBON DIOXIDE PROCESS

by G. D. Haley and J. L. Leach

ABSTRACT

The purpose of this investigation was to determine the interrelated effect of the major variables in the carbon dioxide process. The variables that must be considered are gassing time, gassing pressure, grain fineness of the sand and amount of binder. An important part of this investigation has been the proposal of a standard method of testing the carbon dioxide hardened sands.

EXPERIMENTAL PROCEDURE

Standard Test

The first step in the investigation was the selection of a method of testing the specimens during the course of study. While many types of testing machines were available in this laboratory, the selection of a machine found in most foundries posed a difficult problem. After selecting the specific testing machine, it was decided to investigate the standard tension and compression tests that were specified for use with it.

The carbon dioxide hardened tensile specimens broke at low strengths, and some broke while loading the specimen into the machine. The specimens proved strong in compression, and most of them were beyond the range of the machine. The material to be tested was therefore weak in tension and extremely strong in compression. It was decided to modify the compression test. By reducing the diameter of the specimen to one in., four times the stress could be applied to the specimen.

Thus, almost 1200 psi could be applied to the specimen. This was found sufficient to break all of the cores except the strongest. Tests indicated that testing a one in. diameter specimen in compression would satisfy the requirement of consistency and reproducibility.

Major Variables Effect

The effect of four major variables on the properties of carbon dioxide cores were investigated. These variables were gassing time, gassing pressure, per cent binder and sand fineness. The standard test, described in the preceeding section, was used to study these effects.

G. D. HALEY is Supvr., Met., Welding Dept., WalMet Alloys Co., Dearborn, Mich. and JAMES L. LEACH is Prof. of Mech. Engrg., University of Illinois, Urbana.

Gas pressure was investigated by gassing specimens with different pressures from 4 to 55 psi. Five different sands were tested, which ranged from 38 to 126 Grain Fineness number. The gassing times investigated were 30, 60 and 120 sec. Three binder contents were investigated for each sand – 2, 3 and 4 per cent. The binder which was used was a commercial grade suitable for molds containing no sugar and is available on the open market.

The grain size of each sand was checked by the standard method when it was received from the supplier, and the Grain Fineness number was calculated. In all cases at least 75 per cent of the sample weight accumulated on 3 consecutive screens. The sands were not dried prior to mixing. The CO_2 gas was of a commercial grade and was not dried prior to use.

APPARATUS

The special equipment used in these studies is pictured in Figs. 1-2. A view of the apparatus for gassing the specimens is shown in Fig. 1. Gas from the tank is released through two pressure reduction valves into a ¼-in. diameter tube, then into a warming coil. From the coil the gas flows to the cut-off valve on top, which is controlled by the timer.

After leaving the valve the gas enters the top of the die holder, passes through the specimen and exits below the die. During gassing, the moveable head, shown in Fig. 1 in the down position, holds the die in place to insure all of the gas passing through the specimen. After gassing, the head is raised to allow the removal of the die. The head is moved by an air cylinder which is controlled by a switch on the front of the machine. Figure 2 shows the testing machine with the adapters to hold the one in. diameter specimen used in this investigation in place.

DISCUSSION

In Figs. 3-7, an attempt has been made to graphically show the interrelationships of the variables studied on the strength of hardened cores.

In Fig. 3, the maximum compressive strength is plotted against the mesh size of the sand for each of the binder contents investigated. The values of compressive strength plotted were the maximum strengths obtained for the given sand and binder without regard to the time and pressure of gassing. The curves

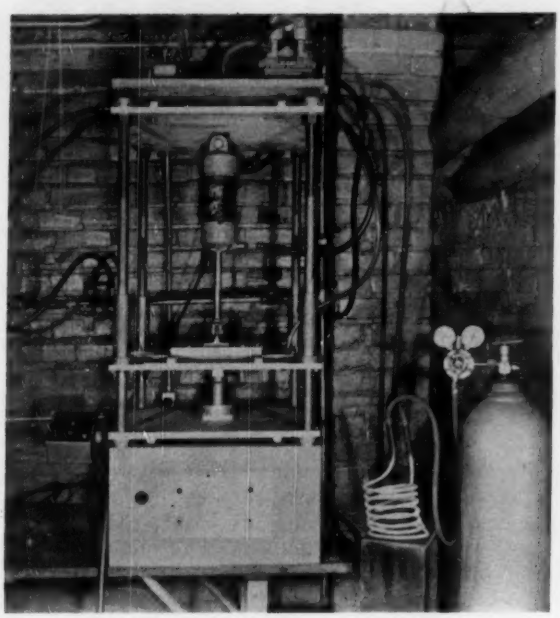


Fig. 1 — Apparatus used for gassing the specimens. Gas from tank is released through two pressure reduction valves into a ¼-in. diameter tube, then into a warming coil. From the coil the gas flows to the cut-off valve on top, which is controlled by the timer.

thus show only the effect of amount of binder and mesh size of the sand.

It is immediately apparent from Fig. 3 that an increase in binder content increases the compressive strength of the hardened cores. This effect appears greater when increasing the per cent of binder from 2 to 3 per cent for all of the sands tested except the finest one. The finest sand requires 4 per cent binder before there is a great change in compressive strength. It is believed that 2 per cent binder forms a thin film around the sand grains, and in many places the continuity of the film may be broken causing low compressive strength.

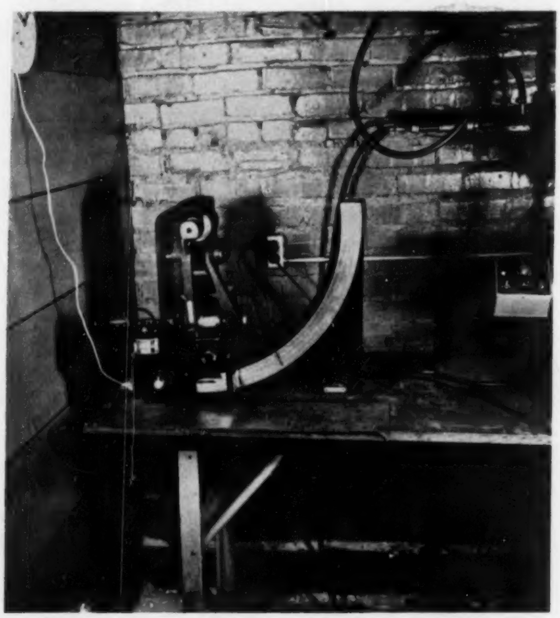


Fig. 2 — Testing machine used on the specimens. Adapters were used to hold the one in. specimen in place.

Additional binder (3 per cent) gives a thicker film, and apparently covers all of the grains. The addition of still more binder only gives a thicker film, and the increase in strength is not as great. The finest sand requires 4 per cent binder before the film is continuous, so there is not any appreciable rise in strength until 4 per cent binder is used.

Another point of interest in Fig. 3 is the effect of grain size on strength of the cores at a constant per cent of binder. It is noted that there is a rise in strength as the grain fineness of the sand is increased until the finer sands are tested. The drop associated with 126 mesh sand is greatest for the lowest per cent binder, and the effect decreases as the per cent increases. This would indicate that, if additional higher percents of binder were tested, there would not be a drop. The strength increases with finer sands because there is more bonding surface present in the finer sands.

It is proposed that the increase in strength is counteracted at 126 mesh by the inability of the binder to form a continuous bond, and hence the strength drops. At 4 per cent binder, there is almost enough binder to form a continuous film and the drop in strength is not as great.

Maximum Strength vs. Mesh Size

In Fig. 4, pressures necessary to produce maximum strength at each gassing time are plotted as a function of the mesh size of the sand. Only the pressures necessary to produce optimum strength at 4 per cent binder are shown. The curves for 2 and 3 per cent binder show the same trend, only to a lesser extent, and are not plotted. Figure 4 shows that shorter gassing times require higher gassing pressures. Using 126 mesh sand and 60 sec gassing time at 15 psi gas pressure will give the maximum strength possible with this gassing time. Shorter gassing times (30 sec) require 50 psi gas pressure, which is more than three times the gas pressure times waste gas.

In addition, the curves show that higher pressures are required to gas fully the finer mesh sands. This effect is greatest for the short gassing time. This is probably due to the finer sands offering more resist-

ance to the passage of gas. Unfortunately, no equipment was available to measure the volume of gas passing through the specimen, but observation was made of the flow rate at higher pressures.

Figure 5 is the same type of plot as Fig. 4, except that time is held constant and the three binder contents are plotted, rather than holding the binder constant and plotting the three different times. The curves now show the pressure necessary to produce maximum strength at different per cent of binder using constant time. All three times produce the same type of curves, but the effect of a 30 sec time is the greatest and is the one plotted.

Figure 5 shows that higher per cent of binder require higher gassing pressures. Since the gassing time is constant, the amount of gas required by the higher binder contents is greater. Again, as in Fig. 4, it is demonstrated that finer sands require higher gassing pressures.

Gassing Time and Pressure Relationship

Figures 4 and 5 show a close relationship between gassing time and pressure. The product of these two variables is a rough approximation of the amount of gas passed through the specimens. Figure 6 is a plot of compressive strength versus this product of gas pressure and time. One sand is considered at different binder contents. A great number of points are plotted, and they show a considerable spread of values for compressive strength. The extreme points are connected so they encompass all of the points for each binder content. Only the sand with mesh size 109 is shown, but the relations hold for all the sands.

Figure 6 shows that the higher binder contents give higher ranges of compressive strength. This was pointed out in Fig. 3, and is further supported by Fig. 6. The peak strength for higher binder contents occurs with larger amounts of gas. This supports Fig. 5, which shows that to harden higher percentages of binder additional gas is needed. Figure 6 shows that maximum strengths are obtained with a relatively small amount of gas compared to the total range of amounts tested.

It was found that the high pressures and short times gave lower values of compressive strengths than long times and low pressures, even though the product was the same in both cases. The decrease in strength at the higher amounts of gas is due to the overgassing effect, and also due to the formation of channels in the specimens caused by the gas passing through at the high velocity associated with high pressure.

It is possible to draw an average curve through one set of points in Fig. 6. This was done for all of the sands and all of the binder contents. Figure 7 shows the curves for all of the sands tested containing 4 per cent binder. It shows that the maximum strength occurs at increasingly higher binder contents as the fineness of the sand increases. All of the maximums of the average curves fall within a narrow range. None of the sands tested required a large amount of

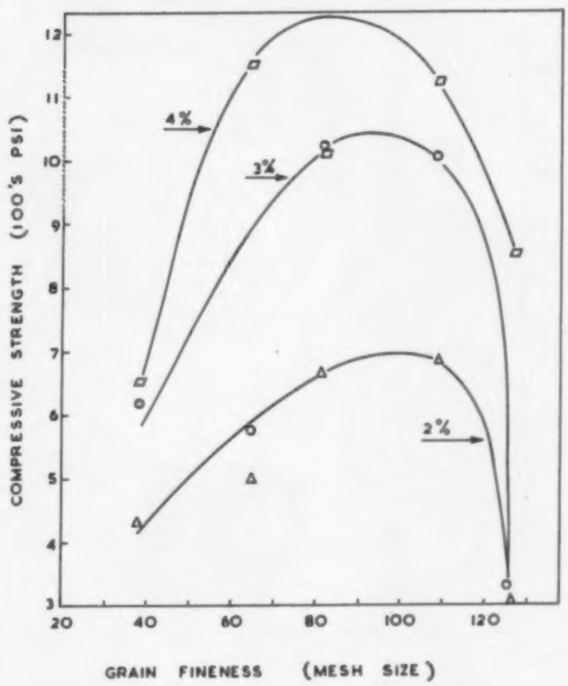


Fig. 3 — Maximum compressive strength obtained from 2, 3 and 4 per cent binder as a function of the grain size of the sand. Gassing pressures and time are not specified on this graph.

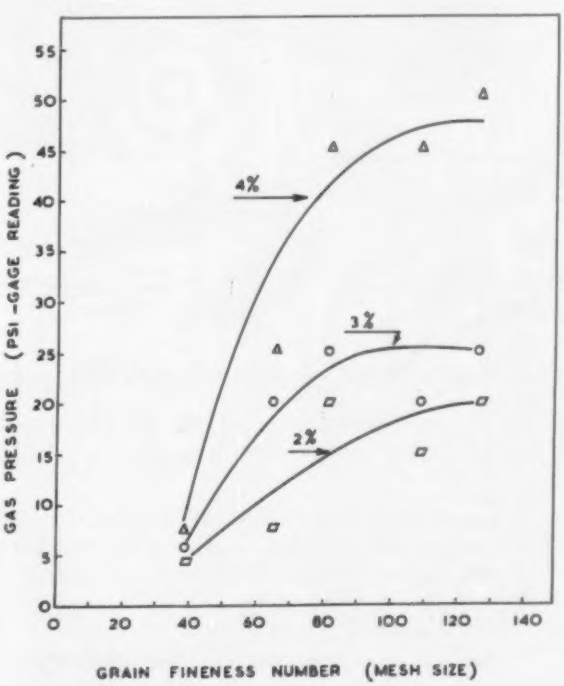


Fig. 4 — Gas pressure to produce maximum compressive strength as a function of grain size of the sand for 2, 3 and 4 per cent binder with 30 sec gassing time.

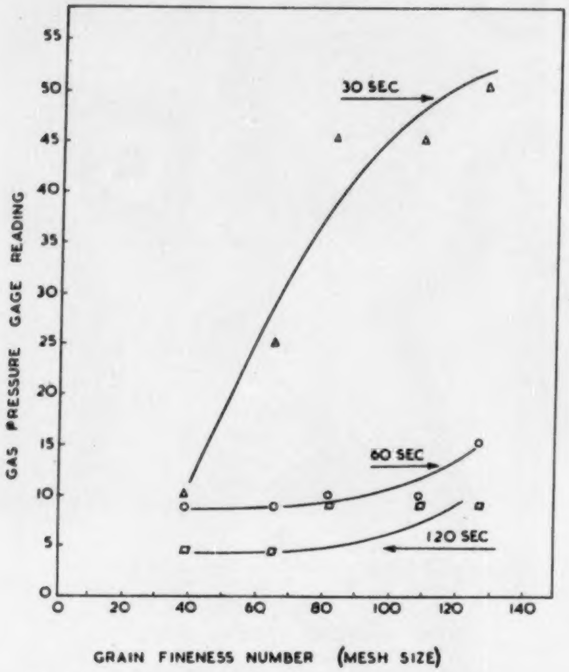


Fig. 5 — Gas pressure to produce maximum compressive strength as a function of grain size of the sand with 4 per cent binder for 30, 60 and 120 sec gassing time.

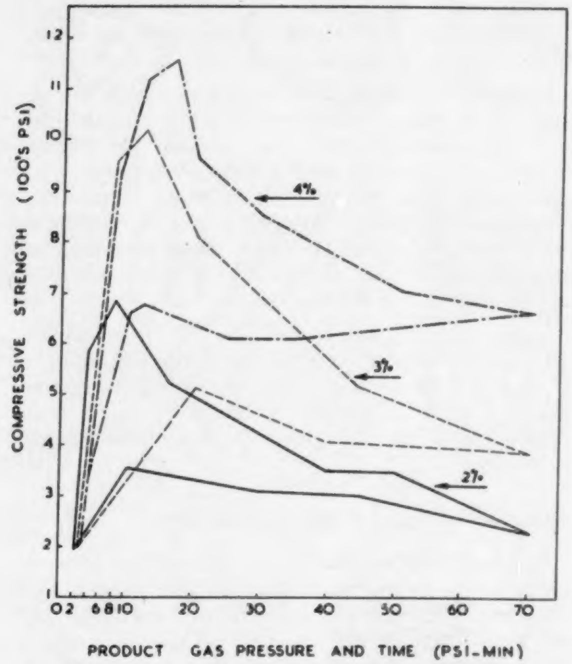


Fig. 6 — Range of compressive strengths as a function of amount of gas passed through the specimen for 2, 3 and 4 per cent binder, the sand being of 109 mesh size.

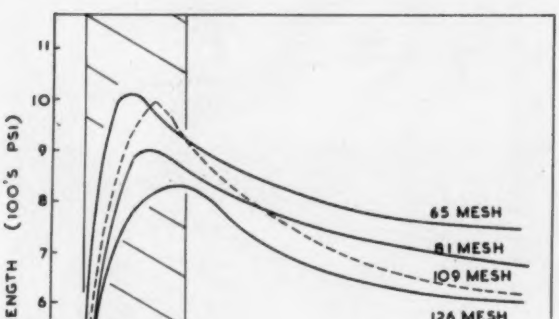


Fig. 7 — Average compressive strength as a function of the amount of gas passed through the specimen for all mesh size sands tested, the sand having 4 per cent binder.

gas for full hardening. All the curves show the characteristics loss in strength with large amounts of gas.

CONCLUSIONS

1. Within the range tested, higher strengths are obtained with higher percentages of binder.
2. The rate of increase in strength decreases with higher percentages of binder.
3. More binder requires a greater volume of gas to develop high strengths.
4. The amount of binder required increases as the mesh size of the sand decreases. Coarse sands do not form strong mixtures. Finer sands form harder mixtures if sufficient binder is present.
5. Shorter gassing time requires higher pressures to obtain high strengths.
6. Higher percentages of binder require higher gassing pressures at constant gassing time.
7. For a specific amount of gas, longer gassing times and lower pressures give higher strengths than shorter times and higher pressures.
8. There is a critical amount of gas that will give the maximum strength for each sand mixture. This amount of gas is higher for the finer sands.

It is the opinion of the authors that these conclusions apply to the CO_2 process in general, and can be proved under most conditions.

You win
savings in the long run! *With Vancoram Chromium Alloys.*

True economy is your prize in the long run when you choose from the comprehensive range of Vancoram Chromium Alloys—because there's one 'just right' for every job you do. And buying 'nearly right' just isn't right enough!

Vancoram Chromium Alloys meet specific needs for makers of stainless, heat-resisting, tool and constructional alloy steels, and for the foundry industry. Choose from high-, medium- and low-carbon grades, including EXLO,® a true ferroalloy with high chromium-to-carbon ratio. Vancoram Ferrochromiums and Ferrochrome-Silicons have a well-earned reputation for cleanliness and uniformity. Your VCA representative can help you select the composition 'just right' for you. Vanadium Corporation of America, 420 Lexington Avenue, New York 17, N.Y. • Chicago • Cleveland • Detroit • Pittsburgh

Be sure to visit us at the Hotel Warwick during the A.I.M.E. Open Hearth Meeting, Philadelphia, April 10 to 12.

VANADIUM
CORPORATION OF AMERICA
Producers of alloys, metals and chemicals

Circle No. 150, Pages 145-146

NEWS and VIEWS

Groups Initiate Joint Research
Deadline Nears for Apprentices
Chapters Co-Sponsor T&RI Courses

1961 Congress Blends Technology with Current Foundry Practice

Latest technical developments combined with trips to the diversified San Francisco area foundry industry await visitors to the 1961 Castings Congress May 8-12.

More than 100 technical papers on techniques, technology, and foundry practices are indicated for the Castings Congress. All phases of the casting and patternmaking industries will be explored. Other areas covered will be mechanization, air pollution, cost control, and plant safety.

With the cancellation of the exposition, considerable more interest is expected in plant visitation program. Many foundries within 30 miles of San Francisco will participate. Final plans have not been made, but visits are expected to include brass and bronze, non-ferrous, gray iron, steel, and several specialty alloy foundries.

Housing applications and advance registration forms have been mailed to members. An early return of these forms is advised; advance registration will save considerable time at the Castings Congress.

Advance registration cards with the $5 fee are to be returned to AFS Headquarters, Golf & Wolf Roads, Des Plaines, Ill. If received prior to April 10, official badges will be mailed in advance of the Congress. Admittance to all Congress and technical sessions is by badge only.

Housing applications are to be mailed to the AFS Housing Bureau, Room 300, 61 Grove St., San Francisco 2. The name of each hotel guest must be listed and a $5 advance registration fee is required for each.

San Francisco Plants Open to AFS Visitors

Final details on the extensive plant visitation program for the 65th Castings Congress are nearing completion. The committee is headed by Chairman Charles R. Marshall, Industrial & Foundry Supply Co. and Co-Chairman Edward S. Valentine, O. L. King & Co.


C. R. Marshall

Other members of the committee are: Paul L. Arnold, U. S. Pipe & Foundry Co.; James S. Campbell, University of California; Art Ciapponi, Vulcan Steel Foundry; I. E. Denning, Service Pattern & Foundry Co.; John Evonow, Pacific Brass Foundry of San Francisco; Michael A. Furey, Mare Island Naval Shipyard; William S. Gibbons, Ridge Foundry; Raymond W. Haun, San Francisco Iron Foundry; Victor Henderson, H. C. Macaulay Foundry Co.

Also: Harold R. Hirsch American Manganese Steel Co.; Donald L. Mason, Superior Electrocast Foundry; Philip McCaffery, General Metals Corp.; Harold Riskus, American Radiator & Standard Sanitary Corp.; Weldon L. Russell, Phoenix Iron Works; Frederick A. Sanders, M. Greenberg's Sons; Benny L. Smith, Empire Foundry Co.; George W. Stewart, East Bay Brass Foundry; E. S. Taylor, Pacific Steel Castings Co.; Richard Warner, Atlas Foundry & Machine Co.; Roy C. Wendelbo, DeSanno Foundry & Machine Co.; and Joe Rogers, American Brass & Iron Foundry.

Develop Special Ladies Program at Congress

A ladies program tailored to take advantage of San Francisco's attractions has been completed. The ladies program is headed by Clayton D. Russell, Phoenix Iron Works. Co-Chairmen for hospitality are Mrs. Samuel Russell and Mrs. John Russo.


C. D. Russell


Mrs. S. D. Russell

The first official event will be a tea in the French Room of the Sheraton Palace Hotel at 3:00 pm, Monday, May 8. Mrs. Donald C. Caudron will be the hostess and Mrs. George W. Stewart the co-hostess. On May 9, a luncheon and a fashion show with an oriental flavor will be held at the Mark Hopkins Hotel. Mrs. Gordon Martin will be hostess and Mrs. J. L. Francis will be co-hostess.

A breakfast tour of the San Francisco shopping area will be held on Wednesday, May 10. Mrs. Philip C. Rodger will be hostess and Mrs. M. E. Ginty co-hostess.

A conducted bus tour will be featured on May 11. Mrs. Hugh F. Prior will be hostess and Mrs. William S. Gibbons co-hostess.

Handbook Committee Seeks Photographs

Photographs of various casting discontinuities are being requested by the Controlled Casting Quality Committee for its handbook revision.

The following pictures are needed:

Core raise, sand fusion, kish, mass hardness (indicating the wrong Bhn as shown by indentations), metal penetration, open grain structure, scars, seams and plates, spot metal or cold spots (particularly non-ferrous), stickers or rates, ram off, rough surfaces, cuts and washes.

Those possessing photographs and a case history are requested to forward them to George Anselman, Anselman Foundry Services, Box 148, St. Charles, Ill., for review purposes.

Circle No. 151, Pages 145-146

Penn State Regional Set for June 22-24

Operational foundry techniques will be stressed at the Penn State 3rd Biennial Foundry Conference to be held June 22-24 at University Park, Pa.

Subjects will be divided into four interest areas, each having a coordinator. These will be:

Sand—Coordinator, Stewart Wick, New Jersey Silica Sand Co., Millville, N. J.; assistant coordinator, Harold Kurtz, Empire Steel Castings, Inc., Reading, Pa.

Gray and Malleable Iron—Coordinator, J. Douglas James, Urick Foundry Co., Erie, Pa.

Non-Ferrous Alloys—Coordinator, George J. Miklos, Westinghouse Electric Co., East Pittsburgh, Pa.

Steel—Coordinator, R. W. Zillman, Pittsburgh Steel Foundry Corp., Pittsburgh, Pa.

Members of the conference committee are: Honorary Chairman, Robert McCord, Pennsylvania State University; Conference Chairman, T. E. Egan, Cooper-Bessemer Corp., Grove City, Pa.; Conference Vice-Chairman, J. T. Gresh, American Brake Shoe Co., New York; Conference Secretary, W. P. Winter, Pennsylvania State University; Conference Treasurer, H. P. Good, Textile Machine Works, Reading, Pa.; Program Coordinators, T. E. Egan and W. P. Winter.

Societies Start Joint Research Investigation

Joint sponsorship of die casting and permanent molding research has been initiated by AFS, the American Zinc Institute, and the American Die Casting Institute. Research will be made into the geometry of gating and runner systems.

A lucite die will be constructed by Dow Metal Products Co. for study purposes. It will be identical to a die used by Aluminum Co. of America for experimental purposes. High speed photographs will be made of the behavior of liquids.

The group meeting at AFS Headquarters, viewed motion pictures in which transparent molds, glycerine and a low melting alloy were studied. The film was provided by C. Norberg of Brown Lipe Chapin Div., General Motors Corp., Syracuse, N. Y.

Attending the meeting were N. Sheptak, Dow Metal Products Co., Midland, Mich., and chairman of the

AFS Research Committee of the Die Casting & Permanent Mold Division; G. F. Hodgson, Doehler Jarvis Div., National Lead Co., Toledo, Ohio, committee vice-chairman; F. C. Bennett, Dow Metal Products Co., chairman of the Die Casting & Permanent Mold Division; S. C. Massari, AFS Technical Director; S. E. Eck, American Zinc Institute; David Laine, American Die Casting Institute; John Moorman, Aluminum Co. of America and E. A. Anderson, New Jersey Zinc Co.

Group Continues Work on Surface Smoothness

Mold surface evaluation is continuing on castings made earlier at a work session by the Sand Division's Mold Surface Committee.

The committee tested surface smoothness on four sand blends having AFS grain fineness numbers of 46, 66, 118, and 131 and bonded with an air setting binder. Testing involved use of a stylus for tracing paths on 1-1/8 in. x 2 in. core specimens.

Steel, cast iron, brass, and magnesium castings were made from these cores and surface obtained on the castings were measured by a number of different methods.

The committee also decided to investigate the effect of different cleaning methods and media.

A sub-committee was appointed to have the as-cast metal disks cleaned by current production methods. Shot blasting will be done on recommendations of the committee and the manufacturer performing the work. Disks will then be remeasured.

An evaluation of three various readings is expected to be completed about April 1.

Joint sponsorship of research in die casting and permanent molds was discussed at a meeting of the AFS Die Casting & Permanent Mold Division Research Committee, the American Zinc Institute, and the American Die Casting Institute.

Clockwise are: G. F. Hodgson AFS Committee Vice-Chairman; N. Sheptak, Committee Chairman; AFS Technical Director S. C. Massari; F. C. Bennett, Division Chairman; E. A. Anderson, New Jersey Zinc Co.; John Moorman, Aluminum Co. of America; David Laine, American Die Casting Institute; and E. E. Eck, American Zinc Institute.

T. E. Barlow, Eastern Clay Products Dept., International Minerals & Chemical Corp., Skokie, Ill., explains a point at the T&RI Cupola Melting of Iron Course. Foundrymen-students are: John Hall, Larson Foundry Co., Grafton, Ohio; Herbert L. Cone, Chambers, Bering, Quinlan Co., Decatur, Ill.; and Harley Transue, Albion Malleable Iron Co., Albion, Mich.

Other instructors in addition to Barlow were: W. R. Jaeschke, Whiting Corp., Harvey, Ill.; V. H. Patterson, Vanadium Corp. of America, Chicago; W. W. Levi, consultant, Radford, Va.; AFS Technical Director S. C. Massari; AFS Director of SH&AP H. J. Weber; and T&RI Training Supervisor R. E. Betterley.

March Courses Feature Chapter Sponsorship

AFS Training & Research Institute courses in March emphasize the cooperative nature and scope of the program. One course will be held in Hamilton, Ontario, Canada, in cooperation with the AFS Ontario Chapter. Another will be held in Birmingham, Ala., in cooperation with the Birmingham Chapter. A third will be held in Chicago and presented solely by T&RI.

The March course schedule:

Preventive Maintenance, March 2-3, Hamilton, Ontario. Presents the basic philosophy of preventive maintenance, emphasizing the critical areas of mechanized operations. Valuable for foremen, supervisors, plant engineers, and management.

Shell Molds and Cores, March 8-10, Birmingham, Ala. A critical study of the process—its application, problems, and practical solutions for cost reduction. Typical case problems are invited for class discussion. Course provides practical instruction for all foundry personnel.

Economical Purchasing of Foundry Materials, March 27-29, Chicago. Up-to-date information provided on all aspects of foundry materials purchasing including inventory control. Valuable for supervisors, engineers, purchasing agents, foremen, and management.

Registration is now open. Make reservations for all courses by course numbers and dates given. Registrations are accepted in order received at AFS Headquarters.

Apprentice Contest Deadline Draws Near

Less than one month remains for completion of local apprentice contests. Chapter, inter-plant, individual plant, and individual entries should be completed by the middle of the month to allow sufficient shipping time in the national contest.

All entries in the national competition must be received at the University of Illinois, Navy Pier, Chicago, not later than 5:00 pm, March 31.

Each entry in the 1961 contest must have an official contest identification tag. On casting entries, tags must be wired to the casting and the contest entry number indicated. On wood pattern entries, each loose piece must be marked with the registry number in black India ink. Metal pattern entries are to have tags and each loose piece marked.

When shipping entries to Chicago, both Prof. R. W. Schroeder, University of Illinois, Navy Pier, and AFS Central Office, Des Plaines, should be notified for tracer purposes.

All contest entries remain the property of the AFS Apprentice Contest Committees. Requests for return of entries must be made at the time of shipment for judging purposes, and all entries returned will be shipped collect. First, second, and third place winners in the national contest cannot be returned earlier than 90 days following the Castings Congress in May.

Contestants shall not be permitted to examine the pattern or blue print prior to entering competition and they must not be informed as to the nature of either the pattern or blue print. Each entry must be the certified work of an individual and completed without consultation, help or advice of any other persons. The first casting poured from the first mold completed shall be the only casting entered by the contestant. All castings must be made in green sand molds only. The use of follow boards or pre-formed support blocks is not permitted in the contest.

American Steel Foundries Continues Steady Pattern of Growth

Despite an era of depressed general business conditions and decreased foundry production, American Steel Foundries, Chicago, reports increased income and sales for its first fiscal quarter ending Dec. 21, 1960.

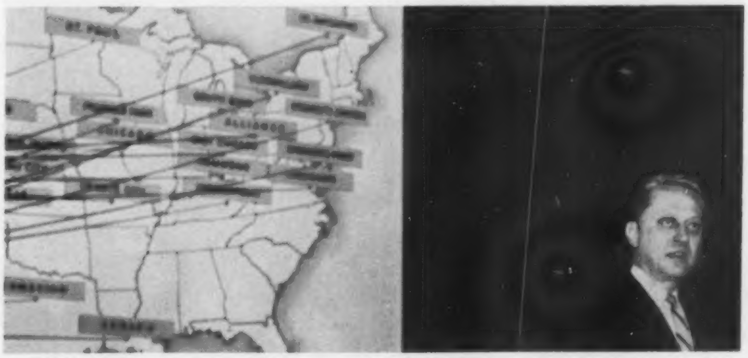
A.S.F. President Joseph B. Lanterman, at a stockholders meeting announced that sales had increased to $28,596,001 from $27,265,155 with net income rising slightly to $1,568,-962 for the quarter. The increases follow the company's pattern—during the past 10 years it has nearly doubled in size.

Railroads are the company's largest customers and cast steel railroad wheels the largest single product. Steps are being taken to diversify sales and thereby decrease dependence on the railroad industry. Steel wheels are made by the patented pressure molding process. Paradoxically, the method is one of the steps toward diversification. The technique is now being licensed for use by others, and considerable application is expected in steel mills for the manufacture of semi-finished mill products.

During 1960 considerable expansion was effected. A research laboratory and pilot plant were completed at Bensenville, Ill. The Council Bluffs, Iowa, plant, formerly a producer of chilled iron railroad wheels, was converted to automated production of cast iron pressure pipe. The foundry at Indiana Harbor, Ind., was converted from a green sand molding operation to a zircon shell molding plan

Work was started on a new plant for the coating and wrapping of pipe in the Youngstown, Ohio, district and construction was started on a new plant for the production of steel wheels at Bensenville, Ill.

Much of the company's success has been traced to research and during 1960 greater efforts were made than previously. The company diverts close to 2-1/2 per cent of its sales dollar into research activities.



American Steel Foundries President Joseph B. Lanterman outlines company's progress at recent stockholders meeting in Chicago. Company continues increasing sales and profits and is diversifying its operations.

CHAPTER NEWS

NORTHEASTERN OHIO—Opening speaker in the four-week symposium on sand problems was Prof. W. G. Lawrence, Alfred University, second from left. Others are Prof. J. W. Wallace, Case Institute of Technology, W. K. Bock, National Malleable & Steel Castings Co., Charles Jelinek, Ford Motor Co., and Harry Leickly, Fanner Mfg. Co.—by Harold Wheeler

MICHIANA—Ferrous and non-ferrous sessions were held recently. Participating were, left to right, Vice-Chairman Vern Compton, LaPorte Foundry Co.; speaker E. C. Mathis, Pickands Mather & Co.; speaker F. L. Riddell, H. Kramer & Co.; and Chairman Walter Ostrowski, Wheelabrator Corp.—by Joseph Lazzara

NORTHEASTERN OHIO—Attending a recent function from Fanner Mfg. Co. are Harry Leickly, Nike Shisoky, Frank Kolis, Tom Shannon, Chester Giera, Ed Roushkolb, Roy Beck, and Robert Hlavin.—by Harold Wheeler

CANTON—A panel discussion of foundry practices was conducted recently. Participating were: Walter Smith, Shenango Furnace Co.; Pat Morgan, Babcock & Wilcox Co.; Nicholas Petros, Canton Malleable Iron Co.; Carl Stansberger and Jerry Hathaway, Massillon Steel Casting Co.; and Mike Wolf, Rockwell Mfg. Co.—by Charles Stroup

WISCONSIN—Practical aspects of quality control were discussed by a local panel. Participating were G. Atonic, Motor Castings Co.; moderator, N. Amrhein, Federal Malleable Co. and AFS National Director; R. Eck, Eck Foundries, Inc.; and E. Gibson, Grede Foundries, Inc.—by Bob DeBroux

UTAH—Participating in a recent meeting were: Secretary William Brown, Treasurer Fred Hafen, Director Joy Nielsen, Chairman Everett Backman, speaker Harvey King, Jr., Pacific States Cast Iron Pipe Co., Claud Cardall, immediate past chairman, and Vice-Chairman Byron MacKay.—by J. M. Bushnell

ST. LOUIS—The impact of modernized European foundries on American metalcasters was explained by C. A. Sanders, American Colloid Co., left. Others are Paul Retzlaff, Chapter Secretary, and Marshall Reichert, Technical Chairman.—by W. E. Fecht

CENTRAL INDIANA—Attending the joint meeting with the A.S.M. Chapter are John Kemp, Hickman-Williams Co., and Tom Teeter and Don Jones of Golden Foundry Co.,—by William R. Patrick

SOUTHERN TIER SECTION—Cupola melting was explained by N. P. Lillybeck, Modern Equipment Co., second from left. Others are Fred Kuster, Ward Casting Co.; C. F. Morken, Kennedy Valve Mfg. Co.; and I. Niles Kitchen, Ingersoll-Rand Co.—by F. H. Troy and Wally Korona

TEXAS—C. F. Lewis, Cook Heat Treating Co. of Texas, explains crystalline structures with models. Lewis discussed fundamentals of heat treatment.—by C. Eugene Silver

Metropolitan Chapter

Modern Core Practices

Production of quality castings through modern core practices were discussed at a recent meeting.

G. M. Etherington, American Brake Shoe Co., noted that advantages of the shell process include elimination of driers, core rods and wires; reduced core breakage; reduced deterioration of cores in storage; and higher production.

In selecting a machine for the jobbing shop, Etherington recommended flexibility as a major factor. He noted that aluminum core boxes are the most widely used, but not necessarily the most desirable, adding that many shops are converting to shell core boxes.

R. M. Overstrud, Reichhold Chemical Co., reviewed self-curing core binders. The newest binders are the hot box variety. He described these as man-made resins, cured by manipulation of their acidity independent of the presence of oxygen. They differ from "no-bake" binders in that they are catalyzed or started to cure in such a way as to have a relatively long bench life until speeded up by a heated core box or pattern.—C. E. Muller

Detroit Chapter

Brake Drum Production

Production of sand cast and centrifugally cast brake drums at the Kelsey Hayes foundry was demonstrated through movies. Melting equipment includes water-cooled cupolas and electric furnaces. Sand molds are made by jolt-squeeze and diaphragm molding methods.

Judge J. G. Rashid, Circuit Court of Michigan, stressed the rights and responsibilities of the individual in politics.—by J. H. Barron, Jr.

Eastern Canada Chapter

Holds Round-Table Session

Various foundry problems were discussed recently at a round-table session dealing with cast iron, steel, and non-ferrous metals. J. Kinsella, Canadian Iron Foundries headed the cast iron section, M. Diorio, Dominion Brake Shoe, led the steel foundrymen, and J. Dick, Montreal Bronze, Ltd., represented non-ferrous.

Among the topics discussed were nodular iron, coke, cupola operations, metal penetration, core veining, CO_2 process, and natural bonded, semi-synthetic, and synthetic sands.—by Jim Cherrett

Texas Chapter

Heat Treat Fundamentals

What happens when metals lose temperature from the liquid state through the solid state and how subsequent heating and cooling affects the metal structure were explained by C. F. Lewis, Cook Heat Treating Co. of Texas, Houston.

The cubic lattice of the solidifying metal and the formation of the dendritic structure was illustrated.

The iron carbon diagram was shown and explained with a description of how it could be used to determine the changes iron goes through in solidifying. "S" curves were described and their application explained for the determination of steel structures under certain cooling rates.

It was shown that metals failed by slippage, and by correcting the grain structure to prevent this slip the metal hardens. The addition of alloys to prevent this slipping was explained with the effect on grain size. It was demonstrated that the use of alloys and heat treatment with fast cooling caused confused facets in the lattice structure making slippage difficult with a resultant increase in strength and hardness.—by C. Eugene Silver

NEW ENGLAND—New equipment for improving shakeout operations was discussed by W. F. Momary, Hewitt-Robins, Inc. New units require less room, eliminate the need for pits, simplify sand handling, and adjust to almost any type of production requirements. Shown are L. W. Greenslade, Jr., Brown & Sharpe Mfg. Co., speaker Momary, and Chairman P. C. Smith, General Electric Co.—by J. H. Orrok

ST. LOUIS—How to avoid erroneous costs in the foundry was explained by R. T. Lewis, Keen Foundry Co., Griffith, Ind. He urged foundries to become better sources of knowledge and information to casting buyers and stressed that savings can also be effected through more intelligent purchasing. AFS National Director W. L. Kammerer also spoke. —by W. E. Fecht

CENTRAL ILLINOIS—Clyde A. Sanders inspects gift mallet given to former AFS President Frank W. Shipley at past chairmen's night.—by Charles W. Search

Utah Chapter

Selecting the Process

Too often foundrymen try to make a job fit a process when they should make the process fit the job, observed R. J. Mulligan, Archer-Daniels-Midland Co.

He stated that a process should help sell the product and cut costs. Before adapting a process, Mulligan recommended a thorough study of the process including its advantages and limitations. Among the processes discussed were CO_2, air-set binders, self-curing binders, shell molding and hot box methods.—by J. M. Bushnell

TRI-STATE—AFS Regional Vice-President Jake Dee, left, emphasized the need for quality control in non-ferrous shops at a recent meeting. On right is Dan Mitchell, Progressive Brass Co.—by Bobby Bell

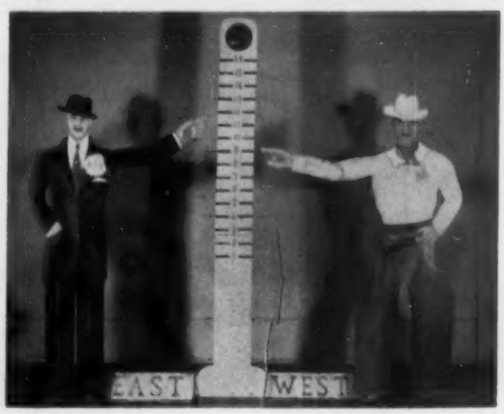
CHICAGO—Production of high grade iron ore from low grade taconite was explained at a recent meeting by E. J. Mapes, Pickands Mather & Co.—by George DiSylvestro

CENTRAL INDIANA—A joint meeting with the Indianapolis A.S.M. Chapter heard R. W. Ruddle, Foundry Services, Inc., discuss solidification of metals. On left is George Sommer, A.S.M. Chairman and on right, Joe Essex AFS Chairman.—by William R. Patrick

CENTRAL NEW YORK—Robert Thurston, Cleveland Tramrail Div., Cleveland Crane & Engineering Co., outlines the latest developments in materials handling. On left is Technical Chairman Robert F. Shea, Crouse-Hinds Co. —by Anthony F. Izzo

SOUTHERN CALIFORNIA—An analysis of various core processes and a look at possible future processes was given by R. J. Mulligan, Archer-Daniels-Midland Co., Cleveland.—by R. V. Grogan

BIRMINGHAM—Chairman E. C. Finch, left, presents $1000 check toward construction of additional facilities at University of Alabama Extension Center in Birmingham to provide full four year engineering facilities. L. S. Woody, is chairman of the Engineers Div., Engineers Club fund raising drive. Inez Fuqua is executive secretary. Chapter has also donated $4000 to underwrite purchase of induction furnace to complete foundry facilities at Auburn University. —by Harry C. Reich



ONTARIO—Membership competition is stimulated between approximately two equal geographical divisions of the chapter. The display is 4-½ ft. high and reflects the improvement in total numbers. In addition, any member who introduces a new member receives a colored ring to slip behind his AFS pin to denote assistance in the campaign.—by Vincent H. Furlong

AFS Chapter Meetings

MARCH 10–APRIL 10

Birmingham District . . Mar. 10 . . Thomas Jefferson Hotel, Birmingham, Ala. . . L. E. Wile, Lynchburg Foundry Co., *"Shell Core Practices."*

British Columbia . . Mar. 17 . . Lougheed Hotel, Vancouver, B. C. . . R. P. Dunn, Lindberg Engineering Co., *"Aluminum Melting Practices and Furnaces vs. Money."*

Canton District . . April 6 . . Elks Club, Alliance, Ohio . . G. Vingas, Magnet Cove Barium Corp., *"Sand Control."*

Central Illinois . . April 3 . . Vonachen's Junction, Peoria, Ill., O. Meriwether, Lynchburg Foundry Co., *"Gating Gray Iron Castings."*

Central Indiana . . April 3 . . Athenaeum Club, Indianapolis . . D. L. La Velle, American Smelting & Refining Co., *"A Simplified Approach To Aluminum Castings."*

Central New York . . March 17 . . Mark Twain Hotel . . J. T. McCarty, General Electric Co., *"Labor Relations."*

Central Ohio . . Mar. 13 . . Shawnee Hotel, Springfield, Ohio . . J. H. Rickey, Jr., Ironton Fire Brick Co., *"Modern Foundry Refractories."* Also *National Regional Directors' Night.* **April 10** . . Seneca Hotel, Columbus, Ohio . . A. Dorfmueller, Archer-Daniels-Midland Co., *"Furan Technology And Its Impact In The Foundry."*

Chesapeake . . Mar. 24 . . Baltimore Engineers Club, Baltimore, Md. . . C. A. Sanders, American Colloid Co., *"Casting Finish and Precision and Tolerance."*

Chicago . . April 3 . . Chicago Bar Association, Chicago . . Non Ferrous: L. L. Charlson, Char-Lynn Corp., *"Zinc Cores In Aluminum Castings."* Iron: C. Walton, Gray Iron Founders' Society, *"Where Are The Foundrymen?"* Sand: C. A. Sanders, American Colloid Co., *"The Foundry Of The Future."* Steel: P. Stevenson, Pittsburgh Metal Purifying Co., *"Application of Exothermic Materials In Jobbing Practice."*

Cincinnati District . . Mar. 13 . . Engineers Club, Dayton, Ohio . . **April 10** . . Wigwam Restaurant, Cincinnati, Ohio.

Connecticut . . Mar. 22 & 23 . . Hammond Metallurgical Laboratory, Yale University, New Haven, Conn. . . *Ferrous and Non-Ferrous Metallurgy Sessions.* **Mar. 24** . . *Dinner* . . St. Elmo's Club, New Haven, Conn.

Corn Belt . . Mar. 17 . . Town & Country Restaurant, Lincoln, Nebr. . . R. L.

Circle No. 162, Pages 145-146 ➞

Olson, Dike-O-Seal, Inc., *"Wood Patternmaking."*

Detroit . . Mar. 16 . .Wolverine Hotel, Detroit . . R. Olson, Southern Precision Pattern Works, *"Pattern Making, Present & Future."*

Eastern Canada . . March 10 . . *"Students Night."*

Eastern New York . . Mar. 17 . . Panetta's Restaurant, Menands, N. Y.

Metropolitan . . April 3 . . Military Park Hotel, Newark, N. Y. . . Round Table, Subject: *"The Repair and Salvage of Castings."*

Michiana . . Mar. 13 . . Club Normandy, Mishawaka, Ind. . . V. R. Fulthorpe, Foundry Service, Inc., *"Chemical Treatment of Non-Ferrous Metals."* A. H. Doerr, Midwest Foundry Co., *"The Shell Game."* . . **April 10** . . Spaulding Hotel, Michigan City, Ind., H. Von Wolff, National Acme Co., *"Shell Cores and New Trends."*

Mid-South . . Mar. 10 . . Claridge Hotel, Memphis, Tenn. . . I. G. Robinson, Lester B. Knight & Associates, Inc., *"Quality Control in the Foundry."*

Mo-Kan . . Mar. 16 . . Fairfax Airport, Kansas City, Kan. . . R. L. Olson, Dike-O-Seal Inc., *"Wood Patternmaking."*

Northern California . . Mar. 13 . . Spenger's Fish Grotto, Berkeley, California.

Northern Illinois & Southern Wisconsin . . Mar. 14 . . Morse Hills Golf Club, Beloit, Wis. . . Robert E. Kennedy Apprentice Awards. *"Panel Night."*

Northwestern Pennsylvania . . Mar. 27 . . Franklin Club, Franklin, Pa. . . H. W. Dietert, Harry W. Dietert Co., *"Todays Sand Control."*

Ontario . . Mar. 24 . . Royal Connaught Hotel, Hamilton, Ont. . . Past Chairmen's Night. G. O. Loach, Union Carbide Canada Limited, *"Whither Canada."*

Philadelphia . . Mar. 10 . . Engineers Club, Philadelphia . . Round Table: *"Use of Alloys, Gray and Ductile, Non-Ferrous Steel."* Speakers: Ralph Clark, John Vogt, Victor Popp of Union Carbide Metals Co.

Pittsburgh . . Mar. 20 . . Hotel Webster Hall, Pittsburgh, Pa. . . H. F. Bishop, Exomet, Inc., *"Risering and Feeding of Steel Castings."*

Quad City . . Mar. 20 . . LeClaire Hotel, Moline, Ill. . . L. D. Pridmore, International Molding Machine Co., *"Mold & Core Blowing."*

Rochester . . April 4 . . Manger Hotel, Rochester, N. Y. . . R. A. Clark, Union Carbide Metals Co., *"Ferroalloys In The Iron Foundry."*

Saginaw Valley . . April 6 . . General Motors Institute, Flint, Mich. . . *"Educational Night."*

Southern California . . Mar. 10 . . Rodger Young Auditorium, Los Angeles . . R. P. Dunn, Lindberg Engineering Co., *"Aluminum Melting Practices and Furnaces vs. Money."*

Tennessee . . March 31 . . Wimberley Inn, Chattanooga, Tenn. . . F. W. Less, Durez Plastics Div., Hooker Chemical Corp., *"Resin Coated Sand And Its Fundamentals."*

Toledo . . April 5 . . Heatherdowns Country Club, Toledo, Ohio . . D. E. Wyman, Exomet, Inc., *"Exothermic Hot Topping & Riserings Of Iron And Steel Ingots And Castings."*

Texas . . Mar. 17 . . Western Hills Inn, Fort Worth . . G. Di Sylvestro, American Colloid Co., *"Hot Sands."*

Timberline . . Mar. 15 . . Oxford Hotel, Denver . . R. L. Olson, Dike-O-Seal, Inc., *"Wood Patternmaking."*

Tri-State . . Mar. 10 . . Tulsa, Okla.

Twin City . . Mar. 14 . . Jax Restaurant, Minneapolis . . W. G. Gude, Foundry Magazine, *"Can We Sell More Castings?"*

Utah . . Mar. 20 . . Provo, Utah . . R. P. Dunn, Lindberg Engineering Co., *"Aluminum Melting Practices and Furnaces vs. Money."*

Washington . . **March 16** . . Engineers Club, Seattle . . R. P. Dunn, Lindberg Engineering Co., *"Aluminum Melting Practices And Furnaces vs. Money."*

Western Michigan . . **April 3** . . Bill Sterns, Muskegon, Mich. . . H. Wilder, Vanadium Corp., *"European Foundry Development."*

Western New York . . **April 8** . . Buffalo Trap & Field Club, Buffalo, N. Y. . . *"Ladies Night."*

Wisconsin . . **Mar. 10** . . Hotel Schroeder, Milwaukee . . Panel Program: *"Is The Customer Getting What He Wants?"* Panel Moderator: J. J. Ewens, Grede Foundries, Inc., Panel Members: K. R. Geist, Allis Chalmers Mfg. Co., J. C. Hanrahan, Northwest Engineering Co., W. Swardenski, Caterpillar Tractor Co.

Future Meetings and Exhibits

March 1-2 . . **Malleable Founders Society**, Technical & Operating Conference. Pick Carter Hotel, Cleveland.

March 5-9 . . **American Society of Mechanical Engineers**, Gas Turbine Conference & Exhibit, Shoreham Hotel, Washington, D. C.

March 11-14 . . **Steel Founders' Society of America**, Annual Meeting. Drake Hotel, Chicago.

March 20-24 . . **American Society for Metals**, Western Metal Exposition & Congress, Pan-Pacific Auditorium, Los Angeles.

March 21-30 . . **American Chemical Society**, Spring Meeting. St. Louis.

April 10-12 . . **American Institute of Mining, Metallurgical & Petroleum Engineers**, Open Hearth Steel Conference. Sheraton Hotel, Philadelphia.

April 12-14 . . **American Institute of Mining, Metallurgical and Petroleum Engineers**, International Symposium of Agglomeration, Sheraton Hotel, Philadelphia, Pa.

April 18-20 . . **Foundry Educational Foundation**, Annual College-Industry Conference. Statler-Hilton Hotel, Cleveland.

April 18-20 . . **American Welding Society**, Annual Meeting and Welding Show. Commodore Hotel and Coliseum, New York.

May 8-12 . . **AFS 65th Castings Congress**, Civic Auditorium, San Francisco.

May 9-11 . . **Material Handling Institute**, Eastern States Show. Convention Hall, Philadelphia.

May 10-12 . . **National Industrial Sand Association**, Annual Meeting. The Homestead, Hot Springs, Va.

May 22-25 . . **American Society of Mechanical Engineers**, Conference and Design Engineering Show, Cobo Hall, Detroit.

May 22-26 . . **American Society of Tool and Manufacturing Engineers**. Engineering Conference and Exhibit, New York.

June 8-9 . . **Malleable Founders Society**, Annual Meeting. The Broadmoor, Colorado Springs, Colo.

June 11-15 . . **54th Annual Air Pollution Control Association Meeting**, Hotel Commodore, New York City.

June 15-16 . . **AFS** Chapter Officers Conference. LaSalle Hotel, Chicago.

June 18-20 . . **Alloy Casting Institute**, Annual Meeting, Hot Springs, Va.

June 18-24 . . **28th International Foundry Congress**, Vienna Imperial Castle, Vienna, Austria.

June 22-24 . . **AFS** Penn State Regional Foundry Conference. Penn State University, University Park, Pa.

Foundry Trade News

American Steel Foundries . . . Chicago, will realign the organizational structure of the Transportation Equipment division to emphasize the company's search for new industrial products. Research developments, including a new shell molding process which produces steel castings to closer tolerances and a controlled pressure pouring process, both having varied applications in foundry and basic steel industries, are expected to accelerate the trend toward diversification.

Alloy Steel Castings Co. . . . Southhampton, Pa., is erecting a new and separate building to house investment casting facilities.

Consolidated Brass Co. . . . Matthews, N. C., has completed a new plant and general offices. The company's foundry saves an estimated $40,000 annually on freight bills for castings which had been purchased in the midwest prior to 1957.

Danko Arlington, Inc. . . . is the corporate name resulting from the merger of Danko Pattern & Mfg. Co. into Arlington Bronze & Aluminum Corp. Danko Arlington, Inc., Baltimore, Md., has 126 employees and over 31,000 square feet of floor space. It has three divisions, pattern, foundry, and machine. Officers are: Chairman of the Board, Joseph O. Danko, Sr.; President, Joseph O. Danko, Jr.; Vice-President, Norbert J. Hynson; Vice-President, Foundry Div., George A. D'Andrea; Vice-President Machine Div., Franklyn C. Weegar; Vice-President, Sales, H. Dorsey Hammond; Treasurer, J. E. Blair; Secretary, A. D. Wallace.

Steel Founders' Society of America . . . launched its centennial observance with a Newcomen address in Philadelphia given by S.F.S.A. President W. H. Moriarty.

Moriarty traced the growth of the steel casting industry from its birth in Buffalo, N. Y., in 1861 to the present time. The first steel castings were made by Buffalo Malleable Iron Works—now the Pratt & Letchworth Div., Dayton Malleable Iron Co. Highlights enumerated included the first castings of commercial value poured by William Butcher Steel Works, Philadelphia in 1867; the first company established exclusively for manufacturing steel castings, Pittsburgh Steel Casting Co. in 1871; green sand molding introduced in 1892; first automotive steel castings in 1905; electric arc furnaces introduced in steel casting industry in 1911; and the peak year in casting production—2,743,000 tons in 1943.

Today the steel casting industry has an annual capacity of 2-1/2 million tons and employs more than 50,000 persons, said Moriarty.

Currently the society is conducting a product development contest to obtain the best examples of new and re-designed products made as steel castings. It is open to students and employees in customer industries, and $10,000 will be awarded for the best entries. The contest closes June 1.

American Die Casting Institute . . . is accepting nominations for the 1961 Doehler Award for outstanding contributions to the advancement of the die casting art. The award consists of a plaque and a cash honorarium of at least $500. Three considerations govern the award: 1) Technical achievement—as measured by significant scientific contributions of a metallurgical or engineering nature relating to the die casting process; 2) Advancements in plant operations—of a management or administrative nature and related to the operational phases of the industry; 3) Other activities not primarily of a scientific or operational nature that result in the enhancement of the reputation and acceptability of die castings. Nominations should be submitted before April 15 with supporting papers or other related materials.

Humble Oil & Refining Co. . . . Detroit, has reorganized its direct marketing divisions. Its Penola Div., which formerly marketed core oils and carbon sand to the foundry industry, now handles wholesale marketing only. The company name of the section marketing these foundry products has been shortened to Humble Oil & Refining Co. Product brand names are being changed from Penola to Humble. Representation and service remain unchanged.

Engineering Castings, Inc. . . . Marshall Mich., has expanded its facilities in green sand, CO_2, shell molding, and dry sand molding methods. Production ranges up to castings weighing 3000 lbs. Many types of alloys are produced including special types for automotive, glass, food and chemical industries.

Wellman Bronze & Aluminum Co. . . . Cleveland, has leased the Dow Chemical Co. sand and permanent mold foundry in Bay City, Mich. The foundry which produces magnesium and aluimnum castings is expected to operate with the present personnel. Dr. Fred J. Dunkerley, vice-president, manufacturing, for Wellman, assumes this position at the Bay City foundry.

George F. Pettinos, Inc. . . . Philadelphia, has streamlined its corporate structure which started in 1959 with the purchase of Sonittep Transportation Co. and the merger of Reading Sand Co. with Bridgeton Sand Co. The remaining American subsidiaries, Bridgeton Sand Co., Cape May Sand & Gravel Co., and Silos, Inc., in New Jersey, A. T. Harris Sand Co. in Pennsylvania and Pettinos New England, Inc., in Massachusetts, were merged into George F. Pettinos, Inc.

Cerro Corp. . . . is new name for Cerro de Pasco Corp., New York.

Racine Foundry & Mfg. Co. . . . Detroit, has formed a new subsidiary, Racine Custom Metalwork Co. Hans B. Nielsen will head the new division which will offer such products as architectural metal work, screens and grills and custom metal furniture.

Lester B. Knight & Associates . . . has received an assignment to staff, at supervisory level, a new steel foundry in Argentina. The new facility, which will be designed by the Knight organization, will produce railroad specialties with a monthly capacity of 1000 tons.

American Industrial Hygiene Association . . . on April 13 in Detroit, as part of its program will present a full day meeting on the industrial noise problems. Included are such topics as evaluation of noise exposures, engineering control, and the handling of noise data. Advance registration is recommended. Requests should be directed to Thomas B. Bonney, Aluminum Co. of America, Alcoa Bldg., Pittsburgh 19, Pa.

Investment Casting Co. . . . Springfield, N. J., has named three sales representatives: James F. Roberts Co., Indianapolis, Indiana area; C. S. Butler & Associates, Cincinnati, southern Ohio area; and Marion T. Davis & Co., Atlanta, Ga., North and South Carolina, Georgia, and Florida.

Let's Get Personal . . .

Peter E. Berry . . . is now director of sales, Thiem Products, Inc., Milwaukee.

N. A. Birch . . . is technical director at Albion Malleable Iron Co., Albion, Mich.

Edward C. Hoenicke . . . is the new president of Caribbean Fabricators, Inc., Fort Lauderdale, Fla. Other changes; **James Daley**, vice president; **Gaylord Thomas**, treasurer; and **Ray Green**, secretary.

Charles C. Jarchow . . . chairman of the board, American Steel Foundries, has retired after nearly 50 years of service. He will continue as a director. The vacancy created by Jarchow's retirement will not be filled. **Marion J. Allen** has been elected as a vice-president and will continue in charge of the personnel and public relations division. **Goff Smith**, an ASF vice-president, will fill the vacancy created by the retirement of **Chauncy Belknap** as an ASF director.

Floyd Sutherland . . . plant metallurgist, Continental Foundry & Machine Div., Blaw-Knox Co., East Chicago, Ind., has retired after 32 years of service. He was chairman of the AFS Radiation Protection Committee and a member of the Safety, Hygiene, and Air Pollution Steering and Program & Papers Committees.

J. S. Philippovic . . . has been appointed manager of the automation and parts department, Syntron Co., Homer City, Pa. He will supervise research, development, production and sales of automation equipment.

Dr. Harold W. Paxton . . . recently received American Society for Metal's $2000 Bradley Stoughton award for outstanding young teachers of metallurgy. Presentation was made during the Society's 42nd National Metal Congress and Exposition.

R. William Rosenquest . . . is manager, metal sales, eastern division, New Jersey Zinc Co., New York. **Charles H. Prince** is manager technical service, metal division.

T. R. Elmblad . . . and **A. C. Kukral** have been named managers of Whiting Corp. New York domestic and Cleveland sales offices, respectively.

Joseph Bertuglia . . . is production manager of the foundry division, International Casting Corp., New Baltimore, Mich. **Thomas Reid** was named superintendent.

Douglas J. Taylor . . . has been appointed ceramic engineer, field services, Ramtite Co., Chicago.

Linwood A. Stedman . . . is manager of the New England district with offices in Springfield, Mass., for Pangborn Corp., Hagerstown, Md.

J. M. Crawford . . . has been made assistant manager for Independent Foundry Supply Co., Los Angeles. Other appointments include: **A. B. Lamb**, to sales manager, and **Lamar Jones** to sales engineer.

August D. Gildemeister . . . and **William K. Knuff** have been named assistant sales managers for Doehler-Jarvis Div., National Lead Co., Toledo Ohio. Also, **Claude E. Robitaille** named plant manager of the Grand Rapids, Mich., plant, and **Clyde E. Claus** made sales manager at Grand Rapids.

Russell Plum . . . appointed plant manager, and **John Strohmaier** named superintendent of Keokuk Steel Casting Co., Keokuk, Iowa.

Frederick C. Irving, Jr. . . . has been made manager of castings sales, Aluminum Co. of America, Pittsburgh, Pa.

Howard W. Brandt . . . made vice president and group executive of National Malleable and Steel Casting Co. He will be in charge of the Industrial Div., as well as the firm's three subsidiaries.

Donald R. Hepler . . . has joined the Brillion Iron Works, Inc., Brillion, Wis., as manager of the firm's foundry division.

Walter B. W. Wilson . . . was elected to treasurer of Basic, Inc., Cleveland.

George H. Johnson . . . named general superintendent of production at Chevrolet Motor Division's gray iron foundry, Saginaw, Mich.

Milton Oakes . . . named foundry superintendent of American Manganese Steel Div., American Brake Shoe Co., Oakland, Calif.

Ralph Tomlin . . . is foundry sales representative of the foundry department of Frederic B. Stevens, Inc., Detroit.

Gerald Lewis . . . named vice-president of marketing and engineering, Cooper Alloy Corp., Hillside, N. J.

John H. Culling . . . is executive vice president of Carondelet Foundry Co., St. Louis, Mo. Other appointments: **A. W. Gruer, Jr.**, vice president of marketing, and **Roy C. Heckenkamp**, secretary-treasurer.

Dan Pendergast . . . made sales representative, New England states, for Foundry Equipment Co., Cleveland, Ohio.

Benjamin J. Imburgia . . . has joined the staff of the Gray Iron Founders' Society, Inc., Cleveland, as field secretary.

Lawrence Froyd . . . promoted to assistant manager of the Buffalo plant of American Machine & Foundry Co.

J. Craig Smith . . . and **Ben S. Gilmer** recently elected to the board of directors of U. S. Pipe & Foundry Co. Smith is president of Avondale Mills, and Gilmer president of Southern Bell Telephone Co.

Sherman B. Burke . . . appointed vice president-sales, for Hanna Furnace Corp., subsidiary of National Steel Corp., Pittsburgh, Pa. Other appointments include: **Roger S. VanDer-Kar** as general sales manager; and **Alden W. Gallup** as Detroit sales manager.

W. C. Capehart . . . has resigned as secretary for the AFS Sand Division Shell Mold and Core Committee (8-N) since joining Dewey & Almy Chemical Div., W. R. Grace & Co.

August R. Canonico . . . is sales representative, industrial sales dept., Magnet Cove Barium Corp., Houston, Texas.

John M. Adams . . . is Los Angeles regional sales manager for Crouse-Hinds Co., Syracuse, N. Y.

Professor Hermann Schenck, (Dr.-Ing., Dr.-Ing. E. (honorary) Metallurgical Institute of Aachen Technical College, and president of the Association of German Ironfounders, has been named an honorary member of the Association of German Foundry-

men (Verein Deutscher Giessereifachleute). He was cited for his metallurgical research and fundamental studies in physical chemistry and thermodynamics of iron alloys, and the furthering of technical and scientific cooperation.

Robert W. Payne . . . named to new post of sales administrator at the Cleveland Div., Precision Castings Co., Cleveland.

Richard R. Kirsop . . . is sales engineer for Theim Products, Inc., Milwaukee. He will cover the Wisconsin territory.

Emil J. Koepsell . . . is special foundry sales and service representative and **William S. Flinchbaugh** is superintendent of foundry and patternshop facilities at Nordberg Mfg. Co., Milwaukee.

Robert M. Green . . . is vice-president and general manager, Metallurgical Associates, Inc., Boston.

J. J. Kroecker . . . is sales manager, Permold Co., Medina, Ohio; **L. E. Groat**, continues as vice-president and director, devoting his efforts to market development.

Herbert J. Cooper . . . is president and chief executive officer of Cooper Alloy Corp., Hillside, N. J., and its subsidiary, Vanton Pump & Equipment Corp. He succeeds **Harry A. Cooper**, founder, who was named chairman of the board.

obituaries

Daniel L. LaMarche, 65, Marion, Ind., president of American Malleable Casting Co. and secretary of Arro Expansion Bolt Co.

Fred E. Canfield, 60, owner and operator of Fred Canfield Sand Co., Kansas City, Kans. He was a charter member of the AFS Mo-Kan Chapter and active from its inception.

W. Henry Cantelon, president, Auto Specialties Mfg. Co. (Canada) Ltd., Windsor, Ontario.

Royce Lee Mobley, 55, co-owner, Wichita Brass & Aluminum Foundry, Wichita, Kans.

William Edwin Hall, 84, chairman of the board of Duriron Co., Dayton, Ohio. He was vice-president from the company's establishment in 1912 until 1930, when he became president. He had been chairman of the board since 1946.

D. E. Cummins, sales engineer, Liquid Carbonic Corp., Div. General Dynamics Corp., Washington, Pa.

William P. Putnam, 91, founder of Detroit Testing Laboratory in 1903, retiring as president in 1948. He was active in many technical societies, assisting in organizing the Detroit Foundrymen's Association and serving as its president.

Arthur Jones, 86, president and chairman of the board of directors, U.S. Smelting & Refining Co., Belleville, Ill. He was the inventor of the company's rotary furnace used in the nonferrous foundry industry and also for reclamation and refining of non-ferrous secondary metal residues, and accumulations.

New Products and Processes

What's new in foundry methods and equipment? Summaries of many are presented below. Circle corresponding number on free postcard, page 145. Mail it to us; we'll do the rest!

Two-Level Conveyor Speeds Molding Without Using Additional Space

Two-level track conveyor offers two conveyors in space occupied by one, allowing molder to stay at work station as molds on wheeled pallets are carried away on top track. Bottom track is used for returning bottom boards and pallets. Nomad Equipment Corp.

Circle No. 1, Pages 145-146

Portable Cobalt-60 Radiography Cameras Feature Longer Life

Portable panoramic radiography cameras are useful in radiographing from 3/4 in. to over 12 in. of steel. Sensitivity attainable ranges from less than one to two per cent of section thickness.

Cobalt-60 is utilized. Relatively long half-life of this material—5.2 years—means source seldom requires replacement, usually only every three to five years. Cameras are fabricated of painted carbon steel, except for stainless steel moving parts, and are filled with lead. All are designed to serve as shipping and storage containers for their source. Radionics, Inc.

Circle No. 2, Pages 145-146

Wet-Mix Refractory Gun Cuts Cost of Emplacing Operations

This wet-mix refractory gun, used primarily for the emplacement of refractory materials onto open hearth furnace skewbacks, backwalls, front walls, port skews and uptakes, makes possible easier, faster and less expensive repairs to hot open hearth and electric furnaces.

Gun enables operators to emplace thick furnace patches at any time during the heat cycle without shutting off fuel and incurring lost production time. Basic Inc.

Circle No. 3, Pages 145-146

Zinc Base Alloys has Improved Qualities for Casting Uses

A new zinc base casting alloy has been developed which, states company, has improved casting properties obtained from the use of an alloy having a low, but controlled magnesium content. New alloy requires use of special high grade zinc of unusually low impurity content. American Smelting & Refining Co.

Circle No. 4, Pages 145-146

Continuous Car Automatic Furnace Features Push Button Control

Continuous car automatic furnace preheats before welding, anneals, and stress relieves after welding. Operation is completely controlled by pushbuttons which open and close furnace doors and move cars in and out.

Both pre-heat and stress relieving furnace are capable of operation to 1650 degrees F., and both may be filled with castings and annealed after welding operations are completed. Walz Furnace Co.

Circle No. 5, Pages 145-146

Controlled Temperature Cabinet Provides Uniform Conditions

Controlled temperature cabinet performs checks in tensile, compression transverse or shear. Text loads from as low as OTO-250 lbs. or as high as OTO-10,000 lbs. can be applied.

Recent improvements are said to make tester more adaptable to a variety of uses. Increased sidewall thickness and positive interlock provide a more uniform temperature. Heating element surface has been increased and an improved thermostat incorporated. Working range is from room temperature to 400 F. W. C. Dillon Co.

Circle No. 6, Pages 145-146

Automatic Cycling Zinc Die Caster Produces Parts up to One Pound

Small, low-cost automatic cycling die casting machine produces good quality hardware-finish castings up to one pound in weight at a high rate of speed.

Basic machine can be operated manually by push buttons. By plugging in timer unit, machine will go through an automatic cycle by a single push button. Brush device mounted over the dies and plugged into the air circuit cleans die faces of dirt and flash.

Unit was specifically designed to produce small zinc castings up to one pound in weight at rate of 1000 shots per hour. DCMT Sales Corp., Div. British Industries Corp.

Circle No. 7, Pages 145-146

Two New Chromium Alloys Improve Quality of Stainless Steels

Two new chromium alloys, 45/38 ferrochrome-silicon and low-carbon blocking chrome, are available.

The 45/38 ferrochrome-silicon is used in production of stainless steels for chromium additions and for reducing metal oxides from the slag back into the bath. Low-carbon blocking chrome is used for low-cost open hearth furnace additions in production of high-yield low-alloy steels and certain defense materials such as armor plate. Union Carbide Metals Co., Div. Union Carbide Corp.

Circle No. 8, Pages 145-146

Clipping Thermometers on Pipe Provides Rapid Readings

Pipe thermometer clips to steam, water, refrigeration, gas and other pipes by means of twin spiral spring clips supplied with each instrument. Units can be attached or removed from pipes in seconds and require no alteration of the pipes. Abrax Instrument Corp.

Circle No. 9, Pages 145-146

For The Asking

Build an idea file for improvement and profit. Circle numbers on literature request card, page 145, for manufacturers' publications.

Seat Belts Save Lives . . . is illustrated booklet. Research statistics show how injuries can be reduced by use of seat belts in autos. National Safety Council.

Circle No. 50, Pages 145-146

Gate valves . . . brochure explains engineering specifications and pressure-temperature ratings, plus showing specific applications. Ohio Injector Co.

Circle No. 51, Pages 145-146

Vacuum type furnaces . . . are described and illustrated in a new 8-page bulletin. Among material depicted are hot-wall vertical retort furnaces, horizontal retort furnaces, and a vacuum atmosphere retort tube for research and pilot plant use. Lindberg Engineering Co.

Circle No. 52, Pages 145-146

High alloy castings . . . five rules to help buyers purchasing castings are presented. Questions and answers show how to obtain best value and lowest price. Included is chart of standard designations and chemical composition ranges for heat and corrosion resistant castings. Alloy Casting Institute.

Circle No. 53, Pages 145-146

Template kits . . . complete kit of full-size tracing templates for jig and fixture components are available. They can be used as overlays for correct location of components on drawings and to check fit. Jergens Tool Specialty Co.

Circle No. 54, Pages 145-146

Monorail stackers . . . and their use in material handling and load storage are explained in detail. More efficient use of storage space is said to be a primary advantage. American Monorail Co.

Circle No. 55, Pages 145-146

Chains and hooks . . . receive detailed analysis in a 30-page booklet. Use and inspection of chains is discussed as well as specifications and purchase cautions. Columbus McKinnon Chain Corp.

Circle No. 56, Pages 145-146

Automated pouring system . . . is described. Brochure tells mechanical specifications and examines use and value of the system in cost saving, slag control, and casting quality. International Automation Corp.

Circle No. 57, Pages 145-146

One-man, one-battery car . . . the compact car for long hop transportation in factories and warehouses is discussed. Booklet tells low cost of operation and versatility. Birdie Co.

Circle No. 58, Pages 145-146

Attrition machine . . . removes surface films from sand grains in neutral or acid pulps. Grain to grain attrition removes such coatings as iron oxide and clay slimes. Denver Equipment Co.

Circle No. 59, Pages 145-146

Flexible tubular conveyor . . . applications are presented in a catalog showing six uses. Capacity chart aids in determining system requirements. Hapman Corp.

Circle No. 60, Pages 145-146

Fluidized bed heat treating equipment . . . for annealing, normalizing hardening, aging, quenching, and isothermal transforming is described. Explains process and presents comparative charts. General Electric Co.

Circle No. 61, Pages 145-146

Multi-bearing takeup frames . . . are described in leaflet. Frames available from stock in 11 sizes, especially designed to accommodate any type bearing—babbitted, bronze, ball or roller—in any two-bolt pillow block with mounting holes up to 5/8 inches. Link-Belt Co.

Circle No. 62, Pages 145-146

Aluminum melting holding furnace . . . for use in permanent mold, sand or die casting plants is described. Special design features and applications are treated. Sunbeam Equipment Corp.

Circle No. 63, Pages 145-146

Chart papers and recording inks . . . are recommended for specific jobs. Analysis of types available and specifications are combined with description of manufacturing processes. Minneapolis-Honeywell Regulator Co.

Circle No. 64, Pages 145-146

Social Security benefits . . . are made clear in a booklet up-dated to include revisions of the law effective at the beginning of 1961. Commodity Research Publications Corp.

Circle No. 65, Pages 145-146

Shell bonding resins . . . and their applications are presented. The pulverized, thermosetting phenolic resin can be used several ways to eliminate resin drift into mold and finning. Schenectady Varnish Co.

Circle No. 66 Pages 145-146

Barite ore density analysis . . . made simpler is subject of data sheet. Old and new methods are compared showing time and accuracy of measurements. Beckman Industries, Inc.

Circle No. 67, Pages 145-146

Buyers' directory . . . of company's products and services is available. Includes information on aluminum, brass, bronze, copper, nickel, silver, rhenium, stainless steel, and zirconium. Information on mill orders from plants is also included. Chase Brass & Copper Co.

Circle No. 68, Pages 145-146

Lubrication, insulation, mold release . . . are subjects of brochure which features applications of all three areas. Illustrates how firms overcame lubrication problems in extreme heat; and achieved better finish on castings with a different mold wash. Acheson Colloids Co.

Circle No. 69, Pages 145-146

Bearing retainer material . . . new alloyed iron material for roller bearing retainers is depicted in literature. Material operates at temperatures up to 800 degrees F; has a coefficient of expansion very close to that of steel; operates very satisfactorily under conditions of boundary lubrication; and permanent expansion or growth at elevated temperatures is low. Rollway Bearing Co.

Circle No. 70, Pages 145-146

Hardened iron, steel rolls . . . catalog details all aspects of firm's manufacturing, hardening, and heat treating processes. Includes sections on heat

Advertised Products March—1961

Yours . . . For Advancing Metalcasting

Are you looking for information on any of the subjects listed in the left hand column? Our Modern Castings advertisers have carefully prepared important material on each of these topics to help advance your metalcasting practices. You will find it on the page shown opposite the subject of your interest.

Technical literature is also available on these and many other subjects. Just circle the correct number on the card below that corresponds to the Circle No. shown with each ad and new product items in "New Products and Processes" and "For the Asking" departments.

Here's your opportunity to build a valuable reference file of new products, processes, and techniques.

MARCH 1961—1

Valid through May 1961

NEW EQUIPMENT AND MATERIALS | **ADVERTISED PRODUCTS**

1	13	25	37	49	61	73	85	97	109	121	133	145	157	169	181	193	205
2	14	26	38	50	62	74	86	98	110	122	134	146	158	170	182	194	206
3	15	27	39	51	63	75	87	99	111	123	135	147	159	171	183	195	207
4	16	28	40	52	64	76	88	100	112	124	136	148	160	172	184	196	208
5	17	29	41	53	65	77	89	101	113	125	137	149	161	173	185	197	209
6	18	30	42	54	66	78	90	102	114	126	138	150	162	174	186	198	210
7	19	31	43	55	67	79	91	103	115	127	139	151	163	175	187	199	211
8	20	32	44	56	68	80	92	104	116	128	140	152	164	176	188	200	212
9	21	33	45	57	69	81	93	105	117	129	141	153	165	177	189	201	213
10	22	34	46	58	70	82	94	106	118	130	142	154	166	178	190	202	214
11	23	35	47	59	71	83	95	107	119	131	143	155	167	179	191	203	215
12	24	36	48	60	72	84	96	108	120	132	144	156	168	180	192	204	216

Please Print and Fill Out Completely to Validate Your Requests

Name

Position

Company

Address

No Postage Stamp Necessary If Mailed in the United States

BUSINESS REPLY CARD
First Class Permit No. 88, Sec. 34.9 P. L. & R.
DES PLAINES, ILL.

Reader Service Dept.
MODERN CASTINGS
Golf and Wolf Rds.
Des Plaines, Ill.

LITERATURE REQUEST SERVICE

Yours . . . For Advancing Metalcasting

Are you looking for information on any of the subjects listed in the right hand column? Our MODERN CASTINGS advertisers have carefully prepared important material on each of these topics to help advance your metalcasting practices. You will find it on the page shown opposite the subject of your interest.

Technical literature is also available on these and many other subjects. Just circle the correct number on the card below that corresponds to the Circle No. shown with each ad and new product items in "New Products and Processes" and "For the Asking" departments.

Here's your opportunity to build a valuable reference file of new products, processes, and techniques.

No Postage Stamp Necessary If Mailed in the United States

BUSINESS REPLY CARD
First Class Permit No. 88, Sec. 34.9 P. L. & R.
DES PLAINES, ILL.

Reader Service Dept.
MODERN CASTINGS
Golf and Wolf Rds.
Des Plaines, Ill.

MARCH 1961—2

Valid through May 1961

NEW EQUIPMENT AND MATERIALS										ADVERTISED PRODUCTS							
1	13	25	37	49	61	73	85	97	109	121	133	145	157	169	181	193	205
2	14	26	38	50	62	74	86	98	110	122	134	146	158	170	182	194	206
3	15	27	39	51	63	75	87	99	111	123	135	147	159	171	183	195	207
4	16	28	40	52	64	76	88	100	112	124	136	148	160	172	184	196	208
5	17	29	41	53	65	77	89	101	113	125	137	149	161	173	185	197	209
6	18	30	42	54	66	78	90	102	114	126	138	150	162	174	186	198	210
7	19	31	43	55	67	79	91	103	115	127	139	151	163	175	187	199	211
8	20	32	44	56	68	80	92	104	116	128	140	152	164	176	188	200	212
9	21	33	45	57	69	81	93	105	117	129	141	153	165	177	189	201	213
10	22	34	46	58	70	82	94	106	118	130	142	154	166	178	190	202	214
11	23	35	47	59	71	83	95	107	119	131	143	155	167	179	191	203	215
12	24	36	48	60	72	84	96	108	120	132	144	156	168	180	192	204	216

Please Print and Fill Out Completely to Validate Your Requests

Name

Position

Company

Address

Advertised Products March—1961

transfer rolls, carburizing, design, special heat treating facilities, dual metal chilled iron rolls, and other products for the industry. Badall Co.

Circle No. 71, Pages 145-146

Shell molding . . . application of shell molds at Hallstead Foundry is depicted, including a description of methods used and various products of the firm. Durez Pastics Div., Hooker Chemical Corp.

Circle No. 72, Pages 145-146

Dial timer . . . bulletin describes new push-button automatic reset dial timer, including complete data on application, installation, specialized functions, electrical data, and basic circuit arrangements for control of up to 4 individual load circuits. Automatic Timing & Controls, Inc.

Circle No. 73, Pages 145-146

Hydraulic power units . . . bulletin completely catalogs 37 new hydraulic power unit models. Pertinent application information is included concerning the company's twelve 1000 and 2000 psi single models and the ten continuous booster models. Hannifin Co.

Circle No. 74, Pages 145-146

pH meter . . . a line-operated, drift-free instrument for making precise pH or millivolt measurements, is described in bulletin. Designed for use in laboratory where accurate measurements are required, offers readings over the full 0 to 14 pH range and millivolt readings to plus or minus 1400 mv. Beckman Scientific and Process Instruments.

Circle No. 75, Pages 145-146

Ceramic lined mills . . . literature depicts low cost ceramic or rubber lined ball mills for wet or dry grinding, for continuous or batch type operations and in sizes from 15 x 21 in. to 8 x 12 ft. High density ceramic linings, buhrstone or rubber linings are available. Denver Equipment Co.

Circle No. 76, Pages 145-146

Blast cleaning barrels . . . booklet, contains brief specifications and dimensions of five sizes of blast cleaning barrels ranging in capacity from 1-1/2 to 18 cubic feet. A number of specific applications are also included showing how companies have utilized the units. Pangborn Corp.

Circle No. 77, Pages 145-146

Portable lamps . . . catalog illustrates line of incandescent, fluorescent, combination, and magnifying lamps. Adjustable units can be used over assembly and inspection benches, machinery, drafting tables, office equipment, and in labs. Luxo Lamp Corp.

Circle No. 78, Pages 145-146

Industrial instruments . . . literature depicts an instrumentation application on an electric furnace at National Welding & Grinding Co. The pit-type furnace, 33 inches in diameter and 84 inches deep, utilizes 208v heating elements which can be connected in series or parallel, depending on temperature requirements. Instruments hold temperatures within plus or minus 1 degree F. Industrial Instruments Div., Barber-Colman Co.

Circle No. 79, Pages 145-146

Vacuum filters . . . brochure explains how vacuum filters work, and catalogs two new types of vacuum filters; one for removing dirt and water, and one for removing oil, dirt and water. Listed in sizes from 1/4 in. pipe thread through standard pipe sizes to 5 in. pipe flanges. Wilkerson Corp.

Circle No. 80, Pages 145-146

Basic mortars . . . a heat-setting, periclase mortar, and a heat-setting ground chrome ore mortar are described in brochure. Periclase mortar is used for laying up basic brick in open hearths, electric furnaces and rotary copper furnaces, while chrome ore mortar is a brickwork leveling compound and furnace maintenance material. H. K. Porter Co.

Circle No. 81, Pages 145-146

Dust and fume control . . . catalog depicts various methods in action, including electrical precipitators, mechanical collectors, combination units, jet-cleaned filters, scrubbers, processors and heaters. Also stressed are services such as preliminary layouts and feasibility studies; designing equipment; engineering drawings; erection of equipment; start-up service; training of crews and inspection. Western Precipitation Div. Joy Mfg. Co.

Circle No. 82, Pages 145-146

Use of olivine aggregate . . . in nonferrous foundry is subject of a recently published bulletin. Cited as a major work in the field. Northwest Olivine Co.

Circle No. 83, Pages 145-146

Air control valves . . . illustrated, digest catalog presents 2-way, 3-way, 4-way and 4-way 5-port poppet type valves in a single complete chart. Air and solenoid pilot operators are illustrated and coordinated in the chart with compatible valves. Inline and sub-base mounted styles are covered. Hoffman Valves, Inc.

Circle No. 84, Pages 145-146

Defining density . . . application data sheet clears ambiguity surrounding the term "density". Attempts to standardize terms by differentiating between substance density, particle density, apparent density, bulk density, surface porosity, total apparent porosity, and bulk porosity. Beckman Scientific & Process Instruments Div.

Circle No. 85, Pages 145-146

Cutting man-hours . . . new four-page report discusses savings possible by mechanizing security, maintenance, and supervisory personnel by utilization of 1-passenger electric-powered vehicle. Sketch sheets and conversion tables enable sketching plant layout and computing savings. Cushman Motors.

Circle No. 86, Pages 145-146

New Books for You . . .

Heat Treatment and Properties of Iron and Steel . . . 40 pages. Thomas G. Digges and Samuel J. Rosenberg, National Bureau of Standards Monograph 18. Superintendent of Documents, U.S. Government Printing Office, Washington 25, D. C. Provides in simplified form a working knowledge of the basic theoretical and practical principles involved in the heat treatment of iron and steel. The effects of various treatments on the structures and mechanical properties of these materials are described. Some theoretical aspects and technical details are discussed only briefly or omitted entirely for better understanding of the general subject. Also contains complete listing of all current structural, tool, and stainless steels and their recommended heat treatments.

Contemporary Problems of Metallurgy . . . 538 pages. A. M. Samarin, translated from Russian. Consultants Bureau Enterprises, Inc., 227 W. 17th St., New York 11. Presents a comprehensive review of the most significant research and industrial applications in the field of metallurgy developed in the Soviet Union. Longest section presents recent Soviet advances in production of steel and pig iron. One chapter is report by three metallurgists from Massachusetts Institute of Technology on their visit to the U.S.S.R.

Induction Heating, Coil and System Design . . . P. G. Simpson. 295 pages. McGraw-Hill Book Company, 330 West 42nd St., New York 36. 1960. Practical procedures needed to design coils, power systems, and generating equipment for induction heat applications are outlined. Economy is stressed as well as technical conditions that must be met. Various processes are described including: low-frequency through-heating, accurate surface hardening, localized metal joining and annealing at high frequencies, and high-speed tin reflow. Fundamental electromagnetic and heat-flow theory are discussed as a basis for formulas from which practical designs can be developed. Considerable theoretical and practical design data are presented in form of curves, tables, nomograms, and illustrations.

Non-Destructive Testing . . . Warren J. McGonnagle, 457 pages. McGraw-Hill Book Information Service. 327 W. 41st St., New York 36. 1961. Physical principles, techniques, advantages, and limitations of various methods of non-destructive testing are covered. Principles which underlie a particular test method form the basis for each of the chapters and special techniques for solving a variety of practical problems are included. Among major testing procedures treated in detail are visual testing, pressure and leak testing, liquid penetrant inspection, thermal methods, x-ray and gamma radiography, ultrasonics, dynamic testing, magnetic and electric techniques, and eddy current methods.

Personal Public Relations and Publicity . . . 32 pages. Industries Publishing Co., Culver City, Calif. Among features are how to hold a press conference, how to write a press release, how to secure good relations with the press, how to publicize an event with a time table of release dates.

Emissivity and Emittance—What are They? . . . 17 pages. Office of Technical Services, U.S. Dept. of Commerce, Washington 25, D. C., PB 161 222. A short instruction course in the fundamentals of radiant-heat transfer processes is presented in a report issued by Defense Metals Information Center, Battelle Memorial Institute. Covers basic information necessary to acquire a working knowledge of the field of radiant-heat transfer. Contains a general survey of the radiation process, definition of terms, a section on basic laws governing radiation, and a discussion of some of the general relationships based on these laws.

Symposium on Applied Radiation and Radioisotope Test Methods . . . 118 pages. American Society for Testing Materials, 1916 Race St., Philadelphia 3. Represents concentrated effort to develop some proposed A.S.T.M. methods of analysis and testing involving the use of radioisotopes as analytical tools. It is hoped that by suggesting ways in which methods involving radioisotopes might be applied to current test methods and research problems, the techniques could be advanced.

Advertisers

Classified Advertising

For Sale, Help Wanted, Personals, Engineering Service, etc., set solid . . 35c per word, 30 words minimum, prepaid. **Positions Wanted** . . 10c per word, 30 words minimum, prepaid. Box number, care of **Modern Castings,** counts as 10 words. **Display Classified** . . Based on per-column width, per inch . . 1-time, $22.00 6-time, $20.00 per insertion; 12-time, $18.00 per insertion; prepaid.

HELP WANTED

INDUSTRIAL ENGINEER
To head Iron Foundry Standards Dept. Experienced in Methods, Time Study, Standard Data.

SALES ENGINEER
With experience in selling quality castings, knowledge of Foundry processes and casting design. **Box C-100 H, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

FOUNDRY FOREMAN
To be responsible for the operation of a nonferrous foundry, a division of a nationally represented manufacturing company, located in the southwest. Must be experienced in aluminum and brass molding, quality control and melting practices on a supervisory level. Desire young man in early thirties with trade school background. Excellent opportunity for good Assistant Foreman who wants to move ahead. Reply should include complete resume, salary desired and references. **Box C-101 H, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

FOUNDRY SUPERINTENDENT
$12,000 to $14,000
for a modern foundry. Will consider top assistant.

FOUNDRY ENGINEER
$9,000 to $11,000
Young engineer looking for assured future. . . Contact Paul Sheldon, in confidence.

MONARCH PERSONNEL
28 East Jackson Blvd., Chicago 4, Illinois

PLANT ENGINEERS
Experienced on layout of all types of foundry equipment, material handling and material flows. Send complete details on work history, education and family status. Include recent photograph. All replies confidential. **Box F-140, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

FOUNDRYMEN
when you need SUPERVISORY or TECHNICAL men why not consult a man with actual foundry experience plus 15 years in finding and placing FOUNDRY PERSONNEL.
Or if you are a FOUNDRYMAN looking for a new position you will want the advantages of this experience and close contact with employers throughout the country.

For action contact: John Cope
DRAKE PERSONNEL, INC.
29 E. Madison St., Chicago 2, Illinois
Financial 6-8700

POSITION WANTED

CHICAGO AREA
GRAY IRON METALLURGIST, acid and basic cupola, general experience all phases of operation, production engineering. Age 49—available. **Box C-103 P, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

IRON ROLL METALLURGIST—Experienced all phases of technical work in roll making and development. Will relocate—travel. Presently employed. **Box C-102 P, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

WANTED TO BUY

WANTED
Beardsley & Piper Mulbaro
Beardsley & Piper Screenerator
Core Blowers—Bench & Floor to 125# Core
Box B-102 W, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.

WANTED
Simpson #3—F Muller or Beardsley Piper #80 1952 or Later. **Box B-103 W, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

WANTED
Foundry Equipment all types "What may be obsolete to you," We may be able to use. **Box B-104 W, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

WANTED
Molding Machines
Osborne 275
Osborne 276
Osborne Rotolifts
Box B-101 W, MODERN CASTINGS,

WANTED
Wheelabrator Tumblast—Rubber belt or Steel Flight Machines 1950 or later. **Box B-105 W, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

ENGINEERING SERVICES

FOUNDRY CONSULTANT — NON-FERROUS Sand casting — permanent mold casting — centrifugal casting — in aluminum — brasses — bronzes — 30% leaded bronze — aircraft quality bearings and castings — **ED JENKINS, West Palm Beach, Florida — PHONE: Temple 2-8686.**

EARL E. WOODLIFF
Foundry Sand Engineer
Consulting . . . Testing
14611 Fenkell (5-Mile Rd.)
Detroit 27, Michigan
Res. Phone **VErmont 5-8724**

FOR SALE

ONE USED #3 UNIT DRIVE SIMPSON MULLER. Good condition. **Box B-107 S, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

HYDRO FILTER DUST COLLECTOR—14000 CFM, 25 H.P., 220-440-60-3 Size 11, Type I Wells Manufacturing Company, Mr. J. T. Moore, 7800 North Austin Avenue, Skokie, Illinois. Phone: INdependence 3-5050.

Detroit Rocking Indirect Arc Electric Furnace Type LFC, 125 KW, Capacity 350 lbs. cold scrap, 500 lbs. of molten metal. Two shells, complete with automatic electrode control, main control panel and power transformers for 12,000 volt primary power supply. All equipment used very little and in excellent condition. Immediately available. Make offer to: **Box B-111 S, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

QUALITY EQUIPMENT
SAVE AT LEAST 50%
CLEARFIELD 610 Sand Mixer
B & P #70 Speedmuller
B & P Motive Speedslinger
10' Top Charge Mltg. Furnace
48" x 42" WHEELABRATOR Tumblast
Your largest dealer for all foundry equip't.
UNIVERSAL Mach'y & Equip't Co.
Box 873, Reading, Pa. FRanklin 3-5103

Casting Quality Chart Reprints

It is still possible to obtain single or quantity copies of the informative, two-color Casting Quality Chart reprinted from the October '60 issue of MODERN CASTINGS.

A personal copy of the chart, which lists casting defects and remedies in easy-to-follow form, is free to readers. Additional copies for convenient plant or office use . . . the chart is suitable for mounting on the wall . . . can be ordered at 25¢ each.

With orders being filled on a first-come, first-served basis, readers are asked to write as soon as possible.

Quantity orders will also be filled promptly.

Circle No. 120, Pages 145-146

The Editor's Forum . . .

Marketing and its profitable application to the metalcasting industry . . . sounds like an important subject to the foundry industry. Well it is. In fact so critical that a special conference keyed to this theme was recently co-sponsored by Walter Gerlinger, Inc. and International Minerals & Chemical Corp. Over 100 foundry executives heard seven experienced industry specialists explain: 1) the basic independence of sales and production; 2) the proper relationship between buyer and seller; 3) the best background for casting salesmen; and 4) ways to combat price competition.

The names of speakers and their subjects are detailed in "Looking at Business", this issue. You should be interested in some of the penetrating and meaningful statements made by these panel members. Here are just a few of the high-lights drawn from this important all-day conference in Milwaukee:

"A casting 'buyer's market' is not a time to beat-down prices but a time for buyer and seller to get prices in proper balance through re-evaluation of methods and a review of quality levels . . . Casting salesmen should have fundamental knowledge of patternmaking and foundry practices plus an engineering degree if possible . . . Salesmen must have authority to call together personnel at his foundry to correct and improve operations.

"The art of founding is fortunately becoming a lost art, but the science of founding is just beginning to assume its proper position in our industrial world . . . Strain gauges and brittle lacquers are two tools that permit foundrymen to evaluate their ignorance factor in design.

"Foundrymen put too much emphasis on metalcasting knowledge and too little on sales ability . . . Casting salesman and his shop superintendent should work together as a team and visit customers together.

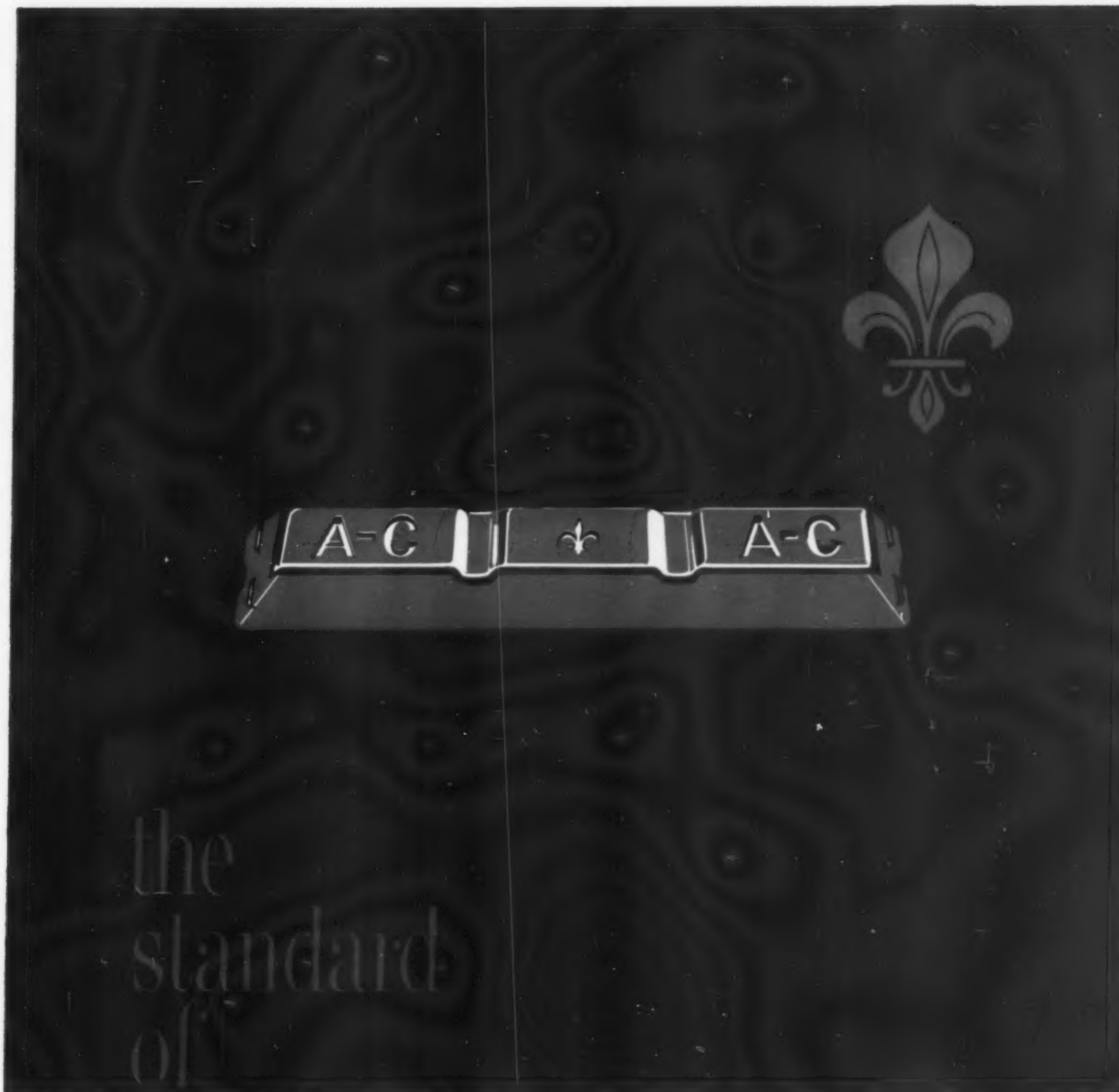
"Improving customer service will gain more sales than price-cutting . . . Unreliability is one of the most serious customer complaints because it can completely disrupt a tight manufacturing schedule . . . Casting prices should not be cut when business is slow, because it actually costs more to produce the same casting when operating rate is lower . . . Every foundry needs a Vice President of Nothing who has no routine duties, just one job—figure out a better way of doing every job so as to reduce scrap, increase yield, lower costs, and produce better castings.

"For a fraction of the money lost on casting rejects, foundries can install adequate quality control systems that will pay for themselves many times over . . . The trend toward automation requires continuous improvement in the quality of purchased castings . . . Modern quality control techniques can reduce internal defects by 50 per cent, visual defects by 80 per cent, and dimensional defects by 80 per cent."

These spot comments reveal the most important thoughts projected by the panel conferees at their foundrymen audience. The complete picture of marketing attitude was displayed by these speakers whose job functions included casting purchasing, casting sales, foundry management, vendor sales, and manufacturing quality control. By learning about all facets of marketing, foundry management came away from the meeting with a realization that survival requires competitive action on many fronts but with one ultimate goal—castings with maximum quality at minimum cost.

Here is another vivid demonstration of how vendors are extending themselves to help foundrymen help themselves. Perhaps this leadership action will stimulate metalcasters to assume some much needed initiative in the area of marketing their products at a profit.

Jack H Schaum


A-C
A-C

Are YOU Using These Proven

FOUNDRY PRODUCTS FROM RCI ?

REICHHOLD PRODUCTS	TYPE	FOUNDRY PROCESS	OUTSTANDING FEATURES
FOUNDREZ 7100 Series	Liquid Resin	CONVENTIONAL CORES	High Hot Strength High Baked Strength
FOUNDREZ 7600 Series	Liquid Resin		Rapid Collapsibility Fast Bake
CO-RELEES 7300 Series	Oil		Excellent Sand Conditioning
coRCIment 7900 Series	Oil		Broad Baking Range Excellent Workability
FOUNDREZ 7150 Series	Liquid Resin	SHELL MOLDS AND CORES	Unusual Stability
FOUNDREZ 7500 Series	Granulated & Powdered Resin		High Tensile Strength Low Gas
COROVIT 7200 Series	Oil & Powdered Accelerator	SELF-CURING	Controlled Curing
REICOTE 7800 Series	Solvent	SAND COATING	Exceptional Coating Speed

For further information regarding any of these materials, write our Foundry Products Division at White Plains

Creative Chemistry . . .
Your Partner in Progress

REICHHOLD
FOUNDRY PRODUCTS

FOUNDREZ *Synthetic Resin Binders* COROVIT *Self-Curing Binders* coRCIment *Core Oils*
CO-RELEES *Sand Conditioning Agent* REICOTE *Sand Coating Agent*

REICHHOLD CHEMICALS, INC., RCI BUILDING, WHITE PLAINS, N.Y.

Circle No. 168, Pages 145-146